BEHAVIORAL CONTRAST AND ALTERNATIVE RESPONSE KEY AVAILABILITY

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An Abstract of a Thesis by

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The Problem. This study investigated the interaction of schedules of reinforcement on behavior, replicating and extending Keller's (1974) research. Expanded methodology included two control manipulations designed to clarify Keller's previously ambiguous findings. The influence of stimulus properties and the location of discriminative stimuli on the production of behavioral contrast was examined.

Procedure. Pigeons in Group 1 were exposed to a two-key procedure in which one key served as the operandum and the other key signaled scheduled consequences (see Keller, 1974). The pigeons in Group 2 were exposed to the same two-key procedure; however, the positions of the keys alternated locations. In Group 3, pigeons were exposed to a two-key procedure in which the key that signaled scheduled consequences was the operandum and the other key was irrelevant with no signal properties or scheduled consequences. All subjects were exposed to a baseline of a multiple variable-interval 1-minute variable-interval 1-minute schedule (*mult* VI 1-min VI 1-min), an experimental phase of a multiple variable-interval 1-minute extinction (mult VI 1-min EXT) and a return to baseline phase.

Findings. Overall, pigeons in Group 1 and Group 2 exhibited negative induction while pigeons in Group 3 exhibited positive behavioral contrast. Pigeons in Group 2 also showed marked responding to the green key which signaled variable-interval 1-minute schedule of reinforcement in the experimental phase, which persisted in the reversal phase. Pigeons in Group 1 showed virtually no signal key pecking. In Group 3, pigeons showed no alternative key pecking.

Conclusions. The results support Hearst and Gormley's (1976) findings that positive behavioral contrast occurs only when discriminative stimuli signaling scheduled consequences are located on the operandum. These findings are also incompatible with additivity theory and Keller's (1974) findings. The results suggest that attentional factors and stimuli salience may serve as crucial variables in the production of the positive behavioral contrast phenomenon.

Recommendations. Subsequent research should attempt to determine whether responses by pigeons in Group 2 to the green signal key associated with reinforcement were the by-product of generalization or constituted adventitious reinforcement. Future research efforts should also show empirical evidence of discrimination and stimulus control.

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CHAPTER I

Introduction

Over the years, numerous researchers have observed phenomena in conditioning procedures which indicate that patterns of behaviors maintained by different distributions of reinforcement are interrelated. In 1927, Ivan Pavlov first observed what is now known as contrast effects and labeled the phenomena positive and negative induction. Regarding his now classic studies on conditioned salivation, Pavlov (1927) described his observations when he wrote that "The secretory effect was increased by almost 50 per cent when the positive conditioned stimulus was applied immediately after the termination of the inhibitory stimulus, and the latent period of the reflex was definitely shortened" (p. 189). The current terminology "behavioral contrast" was later coined by B.F. Skinner in The Behavior of Organisms (1938). Skinner (1938) wrote, "In *Positive Contrast* presentation of the unreinforced stimulus produces a momentary *increase* in the strength of the reinforced member, although a decrease is to be expected from the law of induction. In *Negative Contrast* reinforcement of the reinforced member delays or prevents the reconditioning of the unreinforced" (p.175). These definitions have been altered over time but the term "behavioral contrast" as introduced by Skinner, addresses the single feature common to all the phenomena subsumed under this classification: that is, exposure to various schedules of reinforcement changes behavior maintained by each pattern of reinforcement in isolation (Reynolds, 1961a; Mackintosh, 1974). Reynolds (1961a) later described behavioral contrast as follows:

> A change in behavior during the presentation of one stimulus brought about by changing the schedule associated with another stimulus is called an interaction. The

change in behavior is called contrast when the change in rate of responding generated during the presentation of one stimulus is in a direction away from the rate of responding generated during the presentation of the other stimulus (p. 57).

Behavioral interactions, as defined by Herrnstein and Brady (1958) and Reynolds (1961a; 1961d), occur only under certain conditions and accompany the formation of a discrimination. Currently, four types of behavioral interactions in multiple schedules of reinforcement have been identified; however, they are defined differently from the original conceptualizations of Pavlov (1927) and Skinner (1938). Positive contrast refers to an increase in performance above baseline in the unchanged components of a multiple schedule of reinforcement with a decrease in performance in the components changed to a less dense schedule of reinforcement. Negative induction, conversely, is a decrease in performance below baseline in the unchanged components of a multiple schedule of reinforcement with a decrease in performance in the components changed to a less favorable level of reinforcement. Positive induction is defined as an increase in performance above baseline in the unchanged components of a multiple schedule of reinforcement with an increase in the changed components. Finally, negative contrast refers to a decrease in performance below baseline in the unchanged components of a multiple schedule of reinforcement with an increase above baseline in the changed components (Schwartz & Gamzu, 1977; see Appendix A for diagram). Of these phenomena, positive contrast became a major focus in behavioral research perhaps because this result seemed counterintuitive for the experimental conditions.

The behavioral interaction labeled positive contrast might be described, less technically, as a change in the rate of behavior in the presence of two different stimuli in opposite directions in accordance with a change to a less dense schedule of reinforcement correlated with only one of the stimuli. For example, positive contrast would be observed if the rate of a behavior increased in the presence of a green stimulus correlated with no change in the schedule of reinforcement while the rate of behavior decreased in the presence of a red stimulus correlated with a change to a leaner schedule of reinforcement. Reynolds (1975) explained positive contrast as follows: "When the consequences of a response become less reinforcing in the presence of one stimulus, we can expect the frequency of the response to increase in the presence of another stimulus where its consequences remain reinforcing." Positive contrast, therefore, is an increase in behavior under a constant set of circumstances as a result of the reduction or elimination of reinforcement and a concomitant decrease in behavior under another set of circumstances.

Positive Behavioral Contrast

Although there were numerous efforts to examine the contrast phenomenon (such as Crespi, 1942; Zeaman, 1949; Smith & Hoy, 1954; Findley, 1958; Herrnstein & Brady, 1958; Herrick, Meyers & Korotin, 1959; Collier & Marx, 1959) the definitive paradigm was not outlined until Reynolds' research in 1961(a). Reynolds' landmark experiment served as a catalyst for the investigation of positive behavioral contrast in operant psychology. Reynolds employed a multiple schedule of reinforcement which regularly alternated a red key light signaling one schedule of reinforcement and a green key light signaling the other schedule. During the baseline phase, four pigeons were trained to key peck on a multiple variable-interval 3-minute variable-interval 3-minute (*mult* VI 3-min VI 3-min) schedule of reinforcement. Reynolds' experiment consisted of different phases which were correlated with several changes in the schedule of reinforcement. The shift to a multiple variable-interval 3-minute extinction schedule (*mult* VI 3-min EXT), however, proved to be the schedule change of greatest interest. The introduction of extinction (or the elimination of reinforcement) produced an increase in responding in the unchanged components and a concomitant decrease in responding in the changed components (i.e., positive behavioral contrast). Positive behavioral contrast was also observed as a consequence of other experimental manipulations presented Reynolds' work such as a shift to a time-out component. Finally, Reynolds' reversal to the *mult* VI 3-min VI 3-min schedule of reinforcement (or a return to baseline conditions) re-established responding to baseline frequencies. Reynolds concluded:

> Contrast appears rather to depend upon a relation among schedules of reinforcement currently controlling an organism's behavior. The results of the present experiments and of those summarized in the introduction suggest the following relativistic specification of the conditions for contrast. The frequency of reinforcement in the presence of a given stimulus, *relative to the frequency during all of the stimuli that successively control an organism's behavior*, in part determines the rate of responding that the given stimulus controls. A change in the relative frequency of reinforcement associated with one of several successive stimuli changes the rate of responding during that stimulus; an increase in relative frequency produces an increase in the rate of responding (1961a, p. 70).

There are several aspects of Reynolds' experiment that have developed into typical procedures for the examination of the contrast phenomenon. The use of a variable-interval schedule of reinforcement for unchanged components, the shift from a variable-interval schedule of reinforcement to extinction for changed components, and a single response requirement in both schedules (Schwartz & Gamzu, 1977) are all methodological contributions of Reynolds' work. Reynolds' experiment also stressed the importance of the reinstatement of baseline conditions as a control procedure during the investigation of behavioral contrast (Mackintosh, 1974).

Theories of Contrast

The phenomenon of behavioral contrast has been the subject of conjecture for over twenty years (for reviews see Dunham, 1968; Mackintosh, 1974; Schwartz & Gamzu, 1977). After extensive empirical investigation, a number of interpretations of the behavioral contrast phenomenon have fallen by the wayside (Hearst & Gormley, 1976).

The four theories that have endured time and rigorous empirical investigation include the reinforcement frequency explanation, the response rate reduction explanation (or emotionality hypothesis), the induction explanation and additivity theory. The concept of inhibition is central to all of these conceptualizations except additivity theory (Reynolds 1961a, 1961b, 1961c, 1961d; Bloomfield, 1969; Malone & Staddon, 1973; Terrace, 1963a, 1963b, 1966a, 1966b, 1968, 1972).

The reinforcement frequency explanation proposed by Reynolds (1961a, 1961b, 1961c, 1961d) was based on the research outlined earlier. Reynolds concluded that the behavioral contrast phenomenon was the by-product of an apparent increase in the frequency of reinforcement in the unchanged components relative to the reduction in frequency of reinforcement in the changed components. In several experimental manipulations, Reynolds observed behavioral contrast in schedule changes from a multiple variable-interval variable-interval (*mult* VI VI) to leaner, less favorable, schedules of reinforcement, to differential reinforcement of low rates of behavior and to extinction in the changed component. According to Reynolds (1961c), subjects' "increase in [response] rate during red [signal light for unchanged schedule] occurs only when the absolute frequency of reinforcement correlated with green [signal light for changed schedule] decreases. Thus, the rate of responding during the presentation of red appears to increase as the *relative frequency* of reinforcement associated with red increases, even though the absolute frequency of reinforcement associated with red is constant" (p. 179). Regardless of the fact that reinforcement is held constant in one schedule, reinforcement seems to increase in accordance with diminishing levels of reinforcement previously experienced in the other schedule. In other words, there is an apparent change in the value of reinforcement for the organism. Schwartz and Gamzu (1977) summarized Reynolds' proposal by stating that positive and negative contrast involved a change in a response rate in the direction away from the change in the frequency of reinforcement in the other components.

Inhibition plays a major role in Reynolds' reinforcement frequency explanation of contrast. Reynolds proposed that reinforcement also imposes an inhibitory effect over all behavior. In this explanation, a reduction in reinforcement in one schedule releases inhibition over the behavior in the other schedule. Disinhibition associated with the reduction in reinforcement, therefore, would cause an increase in behavior in the unchanged schedule of reinforcement. Behavior which is released from the inhibition of reinforcement is observed as increased responding in unchanged components with the unchanged schedule of reinforcement concomitant with reinforcement reduction in components with the changed schedule of reinforcement. Catania (1969) supports this premise reiterating that contrast occurs due to a release in inhibition from the previously reinforced component.

Terrace (1963a, 1963b, 1966a, 1966b, 1972) proposed the response reduction explanation (or emotionality hypothesis) of contrast. When Terrace trained pigeons to make a discrimination without errors, the positive behavioral contrast phenomenon was not observed. The paradigm, referred to as 'errorless learning', involved superimposing a multiple variable-interval extinction (*mult* VI EXT) schedule of reinforcement on a variable-interval (VI) schedule of reinforcement such that the pigeon could not respond to the stimulus correlated with extinction. Terrace, therefore, hoped to demonstrate that reduction in response rates, rather than reinforcement frequency (as proposed by Reynolds, 1961a, 1961b, 1961c, 1961d), was the controlling factor in behavioral contrast. The problem with the 'errorless learning' procedure is that response reduction and reinforcement frequency are perfectly confounded in Terrace's experimental paradigm. As a result of criticisms associated with this methodological confound, Terrace (1966a) later restated his explanation to include inhibition as the crucial factor in positive behavioral contrast. Terrace continued to maintain that while response rate reduction was necessary, it was not sufficient to produce behavioral contrast effects. According to Terrace's revised proposal, when an organism must actively inhibit behavior during one component of a discrimination, then the resulting increases in behavior in the other component are "by-products of frustration or similar emotional response" (Terrace, 1966a, p. 617). The emotionality produced from the inhibition of one behavior increases other behaviors. The response reduction explanation, however, failed to account for negative behavioral contrast and induction.

Williams (1965a, 1965b) postulated an induction explanation of contrast based on Pavlov's conceptualization of induction (1927). In the induction explanation, the controlling variable in contrast is the interaction between excitatory and inhibitory gradients inherent in the successive discrimination procedure. An interplay between excitation and inhibition, according to this theory, produces increased performance for a stimulus associated with an unchanged schedule of reinforcement, with decreased performance for the stimulus in the changed schedule of reinforcement. The opposite influences, therefore, result in negative induction. Dunham (1968) explained that "positive induction refers to the fact that a CR [conditioned response] has a shorter latency to a positive CS [conditioned stimulus] if preceded by a negative CS than when it is presented alone. The reverse is negative induction" (p. 308). As with other explanations of contrast, inhibition is a factor.

Additivity Theory of Contrast

Additivity theory, the most recently developed alternative explanation of the behavioral contrast phenomenon, did not postulate inhibition as the controlling variable. Research on autoshaping (Brown & Jenkins, 1968) and automaintenance (Williams & Williams, 1969) served as the basis for additivity theory. The contention of additivity theory, as originally proposed by Gamzu and Schwartz (1973), is that contrast is a result of elicited key pecks evoked by Pavlovian contingencies between the stimulus and the reinforcer. According to additivity theory, during the *mult* VI VI phase of the experiment, response-reinforcer contingencies exist for both components. Differential stimulus-reinforcer contingencies are not in operation. In the change to the *mult* VI EXT phase of the experiment, however, there is an introduction of stimulus-reinforcer contingencies for the VI schedule of reinforcement in addition to response-reinforcer contingencies. Conversely, the stimulus correlated with extinction does not predict reinforcement and, therefore, possess no stimulus-reinforcer dependency. The result of summing the responses generated by each of the two sources of control (stimulus-reinforcer and response-reinforcer contingencies) in operation simultaneously is contrast (i.e., the unexpected increase in responding in the unchanged VI components). Schwartz and Gamzu (1977) maintain that "the additivity theory of contrast is simple: contrast occurs because a differential stimulus-reinforcer dependency is imposed upon an already existing response-reinforcer dependency, and the two sources of control combine to increase the rate of key pecking" (p. 80). Gamzu and Schwartz (1973) and Ricci (1973) have suggested that contrast may merely be the addition of an elicited response to an operant baseline. A number of researchers (Boakes, 1973; Gamzu & Schwartz, 1973; Gamzu & Williams, 1973; Hemmes, 1973; Schwartz, 1973; Rachlin, 1973, Ricci, 1973; Staddon, 1972) have produced results in support of additivity theory and further examined the conditions under which elicited key pecking occurs.

Hearst and Gormley (1976) conceptualized additivity theory differently from other researchers (for example Rachlin, 1973; Ricci, 1973; Gamzu & Schwartz, 1973). Hearst and Gormley (1976) maintained that stimulus-reinforcer contingencies and reinforcer-response contingencies are in effect during the entire experiment and do not become important until after discrimination training is initiated. Stimulus-reinforcer contingencies have an impact during the baseline phase, with the greatest impact during the discrimination phase as the stimulus takes on informative properties with regard to reinforcement. Therefore, the culmination of the stimulus-reinforcer contingencies and reinforcer-response contingencies "provide the main cause of the increased responding during operant discrimination training that is often labeled behavioral contrast, since the explicit response-reinforcer correlation is lowered during discrimination phases (the overall frequency of reinforcement for responding is decreased)" (Hearst & Gormley, 1976, p. 149).

Keller (1974) further developed the notion of additivity theory, suggesting that two different classes of behavior (operant and elicited pecks) are exhibited in the behavioral contrast phenomenon. Keller maintained that the placement of discriminative stimuli on the response key created a confound in standard procedures. Keller attempted to eliminate this projected confound and, therefore, to evoke the separation and measurement two classes of behavior (i.e., elicited and operant reponses) experimentally. Keller (1974) maintained that "stimuli correlated with reinforcement are usually projected upon the operant key" and that "stimulus control of operant responding should develop regardless of the locus of the component stimuli" (p. 250). Keller performed a series of several experiments to analyze this hypothesis.

In a two-key procedure, Keller's (1974) pigeons were exposed to a two component multiple schedule with an operant key illuminated with three white, vertical lines on a black background and a signal key illuminated alternately with a green or red light. There were feedback clicks for responses to the signal key. During a *mult* VI VI schedule of reinforcement, the three pigeons directed responses to the operant key with virtually no responses to the signal key in either component. However, a switch to a *mult* VI EXT schedule produced mixed results across the three subjects. One pigeon did not peck the signal key and showed brief positive behavioral contrast effects to the operant key. There were pecks to the signal key with slight negative induction effects on the operant key which did not total to a contrast effect in the second pigeon's responses. Finally, in the third pigeon's responses, there were pecks to the signal key with temporary contrast effects to the operant key. Keller concluded that "the procedure was only partially successful in generating behavioral contrast" (1974, p. 251). Keller was also interested in what the contrast effect might have been in a single-key multiple schedule for these pigeons.

In a subsequent experiment, Keller (1974) alternated a single-key procedure and a two-key procedure. The two-key procedure was the same as the procedure stated above while the single-key procedure involved superimposing red or green light on the three white, vertical lines. All three pigeons showed a decrease in responding to the operant key (labeled induction by Keller) with an increase in responding to the signal key (labeled contrast by Keller). One of the pigeons displayed high rates of responding to the signal key almost exceeding responding to the operant key which Keller considered to be an "anomaly" (p. 251). Keller (1974) also produced an induction effect in relation to the operant key and a contrast effect in relation to the signal key in a three component multiple schedule. Responses on the operant key were required to obtain reinforcement while the multiple schedules of reinforcement were signaled on the other two keys. One of the three pigeons, however, showed an increase in responding to the operant key and a decrease in responding to the signal key with some signal key responding developing later. Despite the decrease in responding to the operant key, when the operant responses were added to the signal responses the result was positive behavioral contrast.

Based on these results, Keller (1974) came to three basic conclusions. First, elicited key pecks are present in addition to operant pecks in the contrast phenomenon. Second, a two-key procedure employing an operant key and a signal key form a viable experimental procedure for measuring the two distinct classes of behavior--operant and respondent behavior, respectively. Unexpected responses to the operant key, to Keller, were a "partial failure to maintain complete control of elicited pecking" (1974, p. 255). Third, the changes in schedules of reinforcement associated with positive behavioral contrast in a single-key procedure resulted in induction seen in relation to the operant key and contrast in relation to responses on the signal key in two-key procedures. Keller also surmised that the two-key procedure introduced additional variables by altering the quality of the discrimination, adding an additional response requirement (i.e., requiring subjects to change over between the two keys) and the procedure of alternating single-key sessions with two-key sessions.

The strongest empirical support for additivity theory can be found using Keller's (1974) signal-key procedure. There are, however, certain aspects of Keller's assumptions, methodology and projections which warrant further investigation. Keller's (1974) initial findings were, at best, ambiguous. Moreover, positive behavioral contrast, as comprised of elicited and operant responses summed together across the signal and response key, has not proved to be a reliable phenomenon. Positive behavioral contrast is not a universal finding using the signal-key procedure. For example, Williams and Heyneman (1981) offered evidence that a two-second delay (i.e., changeover delay) following the last key peck on a multiple variable-time extinction schedule of reinforcement greatly reduces the key pecking to the signal-key in the signal-key procedure. These findings suggested that adventitious reinforcement plays a significant role in responding made to the signal key. When birds peck (one or several times in succession) on the signal key and then move to the other key which is currently correlated with reinforcement, the initial responses might be reinforced. Reinforcement effects might extend to responding on both keys rather than to the one correlated with reinforcement. Operant contingencies, as opposed to Keller's explanation of elicited responses, could therefore be the determining factor in signal-key pecking.

Research findings such as Williams and Heyneman (1981) suggested that the signal-key procedure involves fundamentally flawed methodology for disassociating elicited and operant behavior as well as for examining the dynamics of an operant procedure. Keller (1974) commented that the procedure was not completely successful in accomplishing a separation of elicited and operant responses as well. Furthermore, alternating sessions of a single-key procedure and a two-key procedure, as Keller did in his 1974 study, defeats the purpose of employing a two-key procedure. If responding to a single-key procedure under conditions similar to the two-key procedure was a point of possible empirical investigation, then a series of systematic extensions should be applied with different experimental groups holding all other variables constant. The role of the changeover response in the two-key procedure should be further assessed to determine the effects on the discrimination as well as on resulting behavior. Moreover, if behavioral contrast is a single unit of behavior, then does a two-key procedure actually interfere with this phenomenon or does it produce another phenomenon altogether?

Rationale and Hypotheses for the Current Experiment

Researchers utilizing different experimental paradigms have not produced consistent or uniform results in numerous attempts to observe positive behavioral contrast effects. Positive behavioral contrast appears to be an elusive and complex phenomenon. Confounding variables and methodological problems may account for the majority of failed empirical attempts to produce positive behavioral contrast. Fundamental questions remain unanswered. For example, what are the precise conditions required to produce positive behavioral contrast? Once the necessary and sufficient conditions for positive behavioral contrast have been identified, existing data may be effectively evaluated and assimilated into a comprehensive theory explaining the contrast phenomenon.

The current experiment attempted to establish certain necessary conditions required to produce the contrast phenomenon. The present experimental procedure was also designed to directly replicate and then systematically extend Keller's (1974) first experiment in order to address his ambiguous findings. These methodological variations may shed new light on the role of variables controlling behavioral contrast. The present experiment examined the effects of the location of discriminative stimuli in a two-key procedure on the occurrence of positive behavioral contrast. In light of Keller's (1974) projections, as well as Hearst and Gormley's (1976) research, it was anticipated that positive behavioral contrast would occur only when the predictive stimulus was located on the operandum. Conversely, positive behavioral contrast was not expected when the predictive stimulus was located off the operandum. Hearst & Gormley's (1976) criticism that baseline stability was not achieved in other studies was also addressed. The current procedure addressed methodological issues stemming from particular theoretical explanations of contrast effects. Given the particular methodology of this research, certain differential predictions were possible based on the various theories of contrast phenomenon.

The emotionality hypothesis (or response reduction explanation) states that positive behavioral contrast is a by-product of frustration or emotionality. According to Terrace (1966a), increasing the difficulty of a discrimination heightens emotionality in an organism and likewise increases the probability of the occurrence of positive behavioral contrast. If Terrace's assumption is correct, then the group experiencing the most difficult discrimination in the current experimental procedure would be the group most likely to show the contrast phenomenon.

Three experimental groups were used and each group addressed the emotionality hypothesis. Group 1 was a direct replication of Keller's (1974) procedure where operant responses directed to a white, center key were reinforced while the left key signaled scheduled consequences on the center key. Positions of the response and signal keys remained constant. In the current experiment, Group 2 experienced the same conditions as Group 1 except that the position of response and signal keys were alternated psuedo-randomly. For Group 3, the discriminative stimuli were located on the response key and an alternative, irrelevant key was present with no signal properties or scheduled consequences whatsoever. As with Group 2, the position of the response key and the alternative key were alternated psuedo-randomly. The discrimination required of Group 3 was projected to be less difficult than the one presented to Group 1 since the discriminative stimuli were located on the operandum for Group 3. The discrimination required of Group 2 was projected to be the most difficult of all due to the separation of the discriminative stimuli and the operandum as well as the positional changes in the keys. If indeed these relative discriminability projections are correct, then Group 2 had the highest probability of exhibiting positive behavioral contrast. Group 3 had the lowest probability of exhibiting contrast and Group 1 was associated with some intermediate probability of showing contrast phenomenon in accordance with the emotionality theory. Furthermore, if heightened emotionality leads to a higher probability of all responses--targeted and interim alike--then responding to the white alternative key with no scheduled consequences should occur at some frequency for Group 3.

If the induction explanation were supported using the current procedure, then the additional sources of excitation provided by the informativeness of stimuli would be crucial in producing behavioral contrast. The organism, however, must attend to stimuli for these stimuli to have informational value. Stimuli associated with nondifferential reinforcement offer no information to the organism and, therefore, lose their discriminative properties and become nonsalient. Organisms cease to attend to nonsalient stimuli. In Keller's (1974) paradigm, which explored behavioral contrast, pigeons may have learned to cease attending to the potential stimuli presented during baseline

Stimuli are nonsalient during baseline, for Group 1, and there is little reason for pigeons to attend to noninformative stimuli. Pigeons in Group 2 were also exposed to noninformative stimuli but may have attended to potential stimulation to some degree due to the changing location of the operant key. At the very least, these birds must have searched for the key which was associated with scheduled consequences. These pigeons were exposed to noninformative stimuli but due to the changing location of response/stimulus keys, continued attention may have been facilitated. The potential stimuli presented in baseline for Group 3 were noninformative due to nondifferential reinforcement, however, attention was maintained by virtue of the fact that potential stimuli were located on the operandum. According to induction theory, Group 3 was the most probable group to show the positive behavioral contrast phenomenon and Groups 1 and 2 should not have shown positive behavioral contrast at all.

According to additivity theory, all three experimental groups should display positive behavioral contrast given that all of the subjects experienced the same change in stimulus-reinforcer and response-reinforcer contingencies from the baseline phase to the experimental phase. The same influences in the experimental phase then make all groups susceptible to the emerging stimulus-reinforcer contingencies that result in positive behavioral contrast.

The paradigm used in the present experiment does not test the reinforcement frequency explanation of positive behavioral contrast. The reinforcement frequency explanation was not examined because a reduction in the frequency of reinforcement was perfectly confounded with all other variables manipulated in the current experiment.

CHAPTER II

Method

Subjects

Fifteen adult, female, experimentally naive Silver King pigeons, purchased from Palmetto Pigeon Plant in Sumpter, South Carolina, served as subjects. Between experimental sessions, all subjects were housed individually and received unlimited access to grit and water. All of the pigeons were maintained at seventy percent of their free-feeding body weight. The birds were randomly assigned to experimental groups. Pigeons H2625, H2660, H3095, H1114, and H2185 were assigned to Group 1 and experienced the standard two-key behavioral contrast signal procedure used by Keller, (1974a). Pigeons H3008, H3064, H2141, H3074, and H2363 were assigned to Group 2 and were exposed to the same two-key behavioral contrast signal procedure used with Group 1 except that the stimuli were projected alternately on the two keys in a pseudo-random order. The remaining five pigeons, H2198, H2703, H2797, H3055, and H3710, were assigned to Group 3 and experienced a two-key procedure in which one key had no relevant scheduled consequences and the other key served as the signal key and the operandum. In Group 3, as with Group 2, the stimuli were projected alternately on the two keys in pseudo-random order.

Apparatus

Daily 64-minute sessions were conducted in five laboratory-constructed standard three-key operant chambers measuring 30 x 30 x 30 centimeters. The three translucent keys were located on the front panel of the experimental chamber. Each of the three keys were 19 millimeters in diameter, and placed 10 centimeters apart, center-to-center. The right-most key was not used and was covered with a metal plate. The keys were positioned at a height of 20 centimeters from the grid floor of the chamber with the middle key centered on the front panel. Keys were adjusted to operate at approximately equal forces of equivalent to the weight of 10 grams. The keys were illuminated with either a white, a green (555 nm) or a red (606 nm) light by a Grason-Stadler E4580 Multiple Stimulus projector unit or an Industrial Electric Engineering Multiple Stimulus projector unit located behind the front panel of the chamber. An unshielded 28 volt d.c. bulb (No. 1820 ux) served as a house light. The house light was located 24.5 centimeters above the grid floor and 1.5 centimeters from the ceiling of the chamber in the upper right-hand corner of the front panel. The house light was lit during scheduled presentations. Between the presentation of components there was a ten second black-out in which the house light and key lights were not illuminated. Experimental sessions were begun and terminated with all sources of light off in the experimental chamber.

The food hopper was located below the center key with the aperture five centimeters from the center point of the front panel and four centimeters from the grid floor of the chamber. Reinforcement consisted of a three-second presentation of Des Moines Feed Company Mixed-Grain Flyer Feed. During reinforcement presentations, the hopper aperture was illuminated by a 28 volt d.c. bulb - No. 1820x.

The experimental chamber was enclosed in a 60 x 40 x 40 centimeter Coleman cooler which provided sound attenuation. Extraneous noise was masked by the sound of a ventilation fan mounted on the back wall of the Coleman cooler and a Gerbrands Masking Noise Generator (Model G4651) supplied continuous white noise, through a speaker, in each experimental chamber. The chambers were controlled, and experimental events recorded, by conventional electromechanical equipment. The electromechanical equipment was located in an adjacent room to eliminate auditory feedback from the equipment.

Procedure

Experimental sessions were conducted seven days a week. During the first session of the experiment, pigeons were shaped to approach and eat from the food hopper. In the subsequent session, subjects were shaped by successive approximation to peck the center key. The center key was illuminated with a white light for Group 1 and Group 2 during shaping procedures. For Group 3, the center key was illuminated with a green (555 nm) light during shaping procedures. Forty consecutive key pecks to the center key were reinforced on a continuous schedule of reinforcement (CRF) for the following two experimental sessions. During the fifth and sixth sessions, the birds in Group 3 were reinforced on a CRF schedule of reinforcement for forty consecutive pecks to the center key illuminated with a red (606 nm) light. The pigeons in Groups 1 and 2 continued to be reinforced on a CRF schedule of reinforcement for forty consecutive pecks to a center key which remained lit with a white light. For the seventh and eighth sessions, the stimulus conditions for each component were in effect on both keys with a ten second black-out added between components, and responses were reinforced on a multiple variable-interval 15-seconds variable-interval 15-seconds (*mult* VI 15-sec VI 15-sec). Subjects were exposed to a *mult* VI 30-sec VI 30-sec schedule for two sessions and then moved to a *mult* VI 1-min VI 1-min until all subjects responded readily. The baseline phase of the experiment for Groups 1, 2 and 3 consisted of 38, 26 and 28 sessions, respectively, on a *mult* VI 1-min VI 1-min schedule of reinforcement.

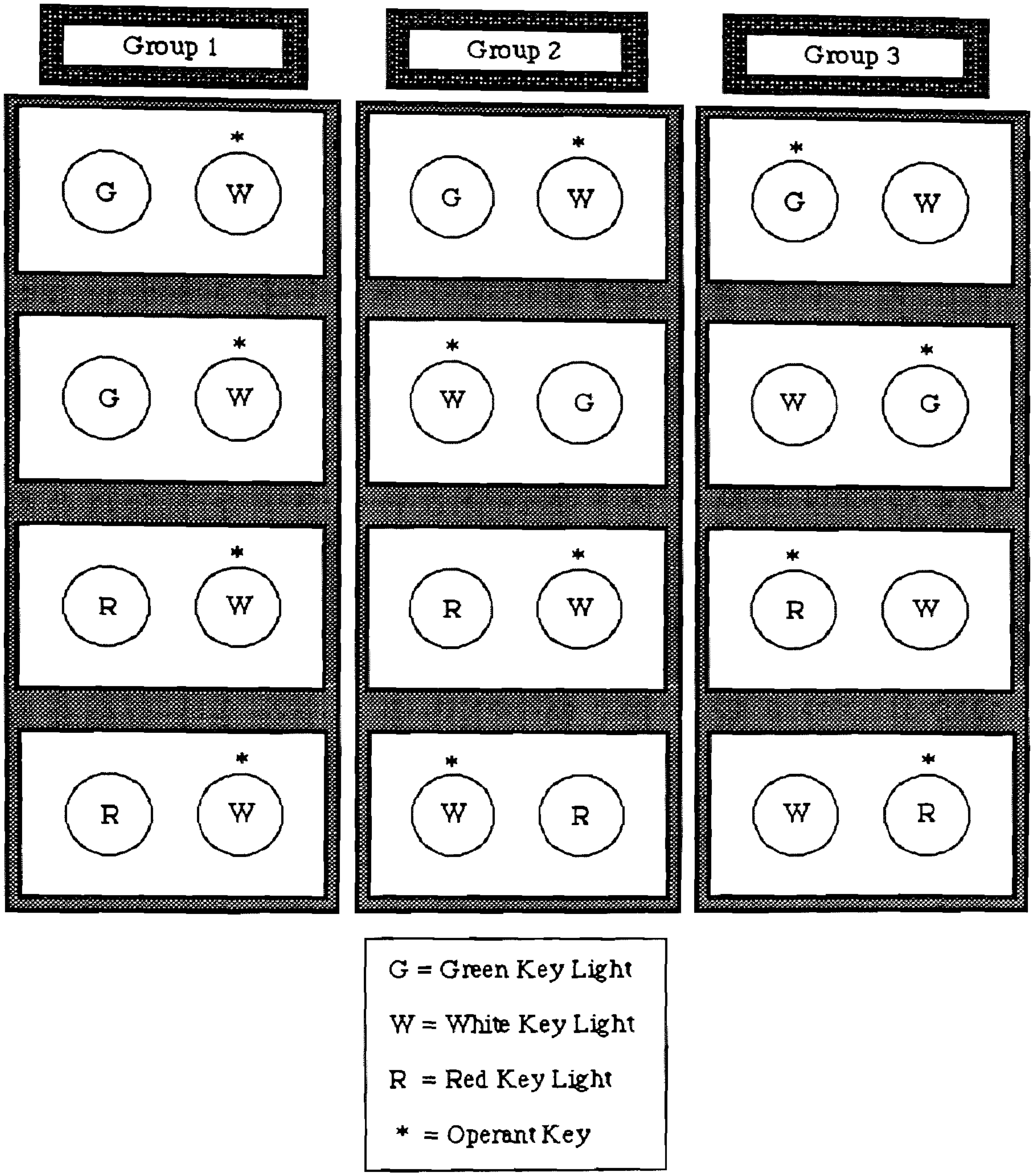
For Groups 1 and 2 during baseline, the first VI 1-min schedule of reinforcement was signaled by a green key light and the second VI 1-min schedule was signaled by a red key light. Reinforcements were delivered for responses to the white key. For Group 3, during baseline, a VI 1-min schedule was correlated with a green key light and the subsequent VI 1-min schedule of reinforcement was correlated with a red key light. For pigeons in Group 3, responses to the red or green key lights were reinforced. The white key light served as an alternative and irrelevant response key.

Responses to each of the stimulus combinations in all groups were recorded separately by mechanical counters. A ten percent stability criterion was employed before the experimental phase was implemented. The ten percent stability criterion required that the total number of responses in each component, for each subject in a group, could not vary more than ten percent across the five baseline sessions preceeding the experimental phase.

Experimental sessions consisted of the presentation of 32 two-minute components. For subjects in Group 1, the center, or operant, key was white while the left key or signal key was green during half of the scheduled components and red during the other half of the scheduled components. The signal key had no scheduled consequences but signaled scheduled consequences were on the operant (white) key for Group 1 (see Figure 1). For Group 2, the operant key was white and the signal key was green for half of the scheduled components and then red for the remaining components. The stimuli associated with the operant and signal keys were presented on both keys in a pseudo-random order so that no more than three presentations of one component appeared in a series within a particular session for Group 2. Once again, the signal key (red or green) had no scheduled consequences but signaled scheduled consequences related to the operant (white) key for Group 2 (see Figure 1). Finally, for Group 3, the stimuli were presented on the keys in the same fashion as in Group 2 except that the operant key was either green or red and the white key was irrelevant--i.e., possessed no relevant signal properties or scheduled consequences (see Figure 1).

The VI 1-min VI 1-min schedule of reinforcement was changed to VI 1-min Extinction (EXT) schedule during the experimental phase of the experiment. The

Figure 1. The scheduled components for Group 1 using the traditional two-key behavioral contrast procedure (Keller, 1974). The scheduled components for Group 2 using a modified two-key behavioral contrast procedure. The scheduled components for Group 3 using a modified two-key behavioral contrast procedure. The operant key in each component indicated by the asterick. The "W" symbolizes the key illuminated with a white light while the "G" and "R" symbolize the key illuminated with a green and red light, respectively.


Group 1
Group 2
Group 3
G = Green Key Light
W = White Key Light
R = Red Key Light
* = Operant Key

VI 1-min components were signaled by a green key light and EXT components were signaled by a red key light for Group 1, Group 2 and Group 3. The experimental phase for Groups 1, 2 and 3 consisted of 45, 45 and 44 daily sessions respectively.

In the third and final phase of the experiment, the VI 1-min VI 1-min schedule of reinforcement was reinstated for all birds. This post-experimental or reversal phase consisted of the precise stimulus and schedule conditions that were in effect during the baseline phase. The reversal phase of the experiment for Groups 1, 2 and 3 continued for 21, 22 and 21 sessions respectively.

CHAPTER III

Results

Results are shown in Figures 2 through 9 and Appendices B, C, D and E. Tables 1 through 3 contain mean responses and response ranges across blocks of sessions in each phase of the experiment for all groups. All figures and tables present data for two component types in which the first component type, signaled by a green key light, was always associated with a variable-interval 1-minute schedule of reinforcement and in the second component type, signaled by a red key light, the schedule changed from a variable-interval 1-minute in baseline to extinction in the experimental phase and to a variable-interval 1-minute during the reversal phase. When all subjects within a group met a ten percent stability criterion for a minimum of five consecutive sessions, the experimental phase was introduced. These requirements for shifting from baseline to the experimental phase were employed for each group.

Figure 2 (also see Appendix B), depicts individual performances of each subject in Group 1, where number of responses to the operant key were summed with responses to the signal key for both component types across all sessions. Group 1 results are presented in Figures 2 and 3 to show that group data are analogous to individual data. Summary data presented for each group allowed projections related to general trends across subjects within a group to be clearly evaluated.

Figure 2 clearly indicates no evidence of positive behavioral contrast in the response patterns of the five subjects in Group 1. Even when operant and signal key responses were summed, no evidence of positive behavioral contrast was observed. During the extinction components of the experimental phase, increased responding to the operant

Figure 2. The total number of responses across sessions for individual subjects in Group 1. The darkened circles show responses to the white operant key in the presence of a green signal key summed with responses to the green signal key. The empty circles show responses to the white operant key in the presence of a red signal key summed with responses to the red signal key. The solid, vertical lines show the point at which the baseline phase changed to the experimental phase and the experimental phase changed to the reversal phase.

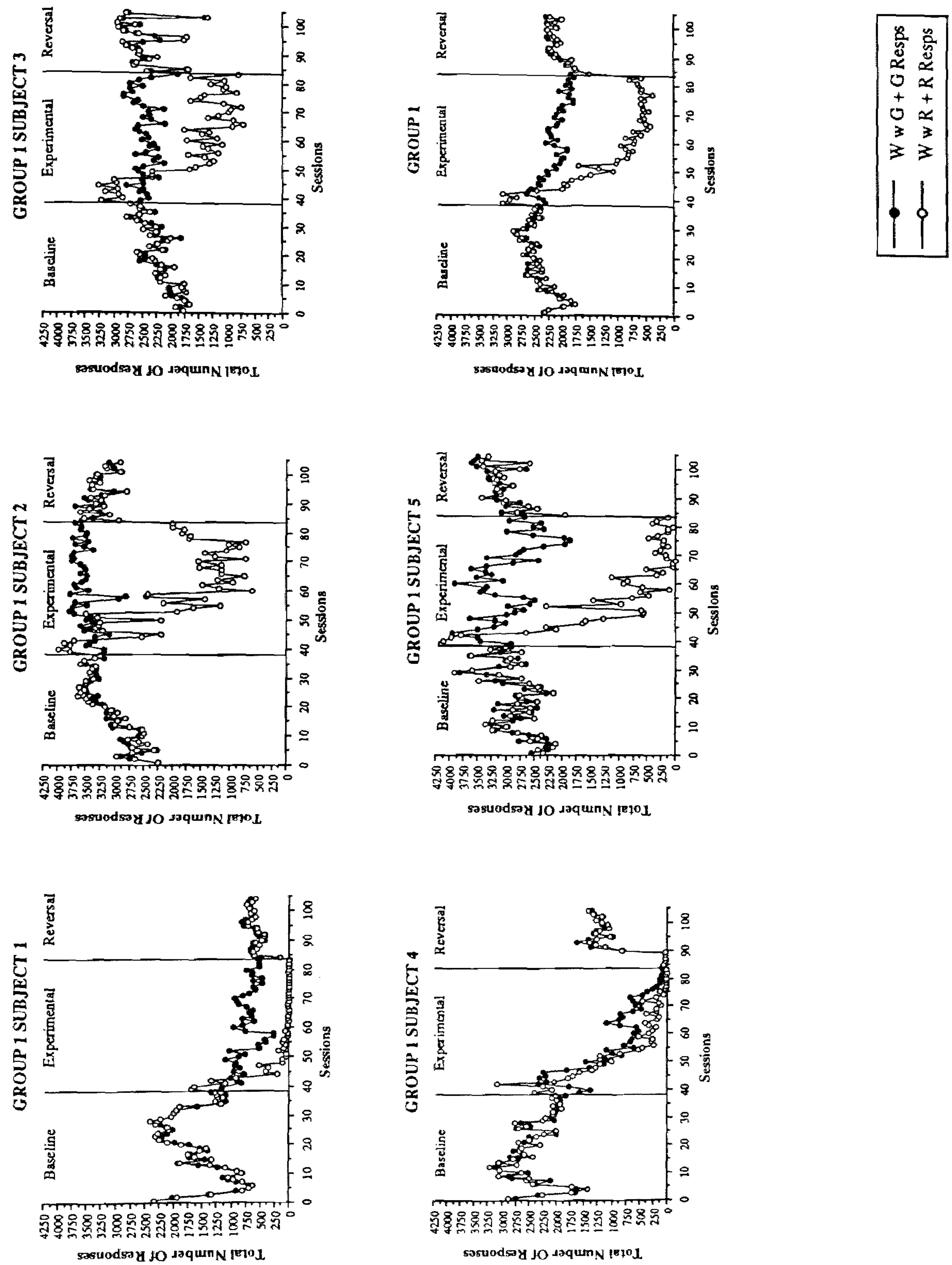

GROUP 1 SUBJECT 1
GROUP 1 SUBJECT 2
GROUP 1 SUBJECT 3
GROUP 1 SUBJECT 4
GROUP 1 SUBJECT 5
GROUP 1
Baseline
Experimental
Reversal
Sessions
Total Number Of Responses
W w G + G Resps
W w R + R Resps

Figure 3. The total number of responses across sessions for individual subjects in Group 1. The open circles show responses to the white operant key in the presence of a green signal key. The open diamonds show responses to the green signal key. The darkened squares show responses to the white operant key in the presence of a red signal key. The darkened diamonds show responses to the red signal key. The solid, vertical lines show the point at which the baseline phase changed to the experimental phase and the experimental phase changed to the reversal phase.

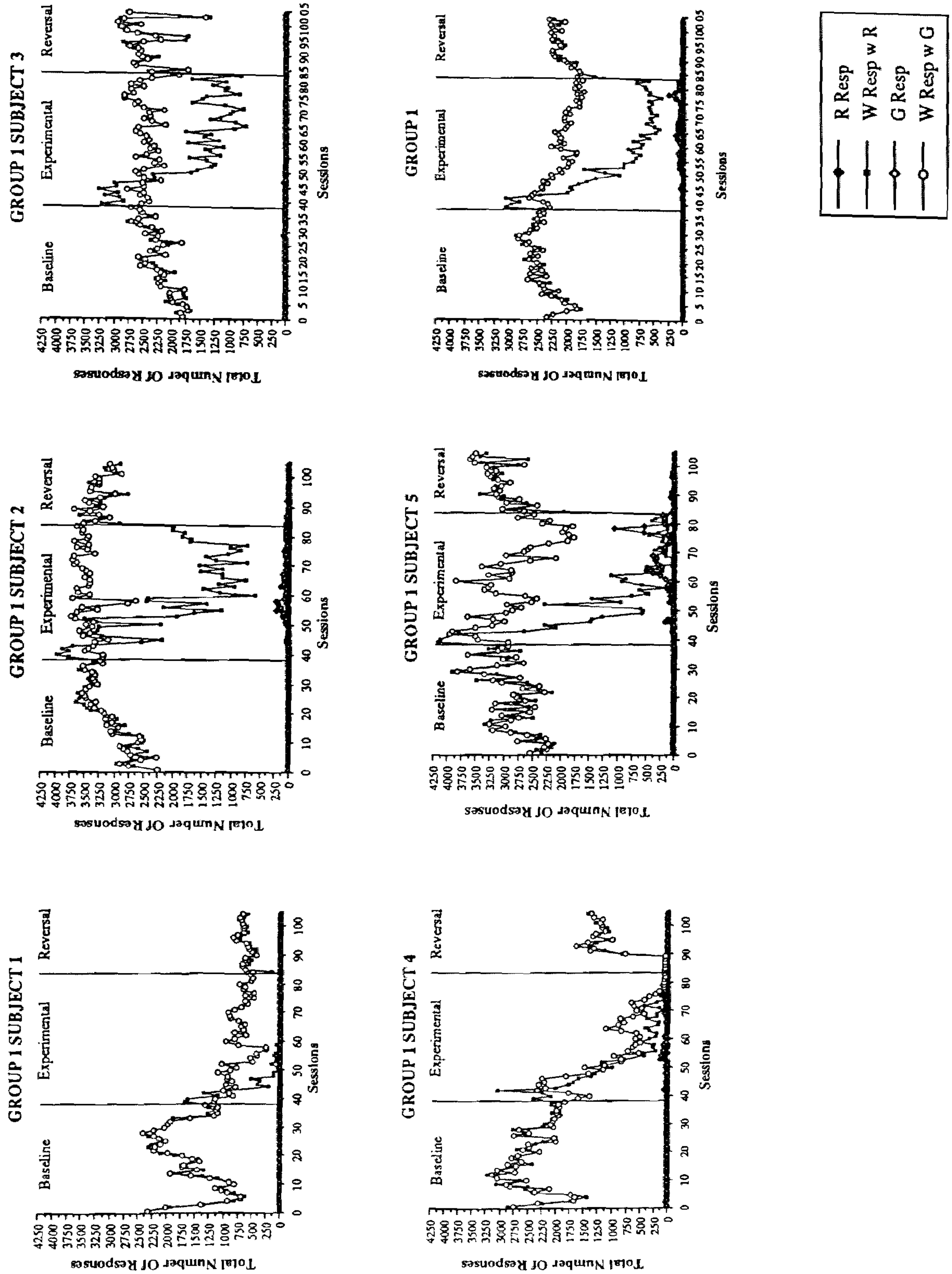

GROUP 1 SUBJECT 1
GROUP 1 SUBJECT 2
GROUP 1 SUBJECT 3
GROUP 1 SUBJECT 4
GROUP 1 SUBJECT 5
GROUP 1
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
R Resp
W Resp w R
G Resp
W Resp w G

Figure 4. The total number of responses across sessions for individual subjects in Group 2. The darkened circles show responses to the white operant key in the presence of a green signal key summed with responses to the green signal key. The empty circles show responses to the white operant key in the presence of a red signal key summed with responses to the red signal key. The solid, vertical lines show the point at which the baseline phase changed to the experimental phase and the experimental phase changed to the reversal phase.

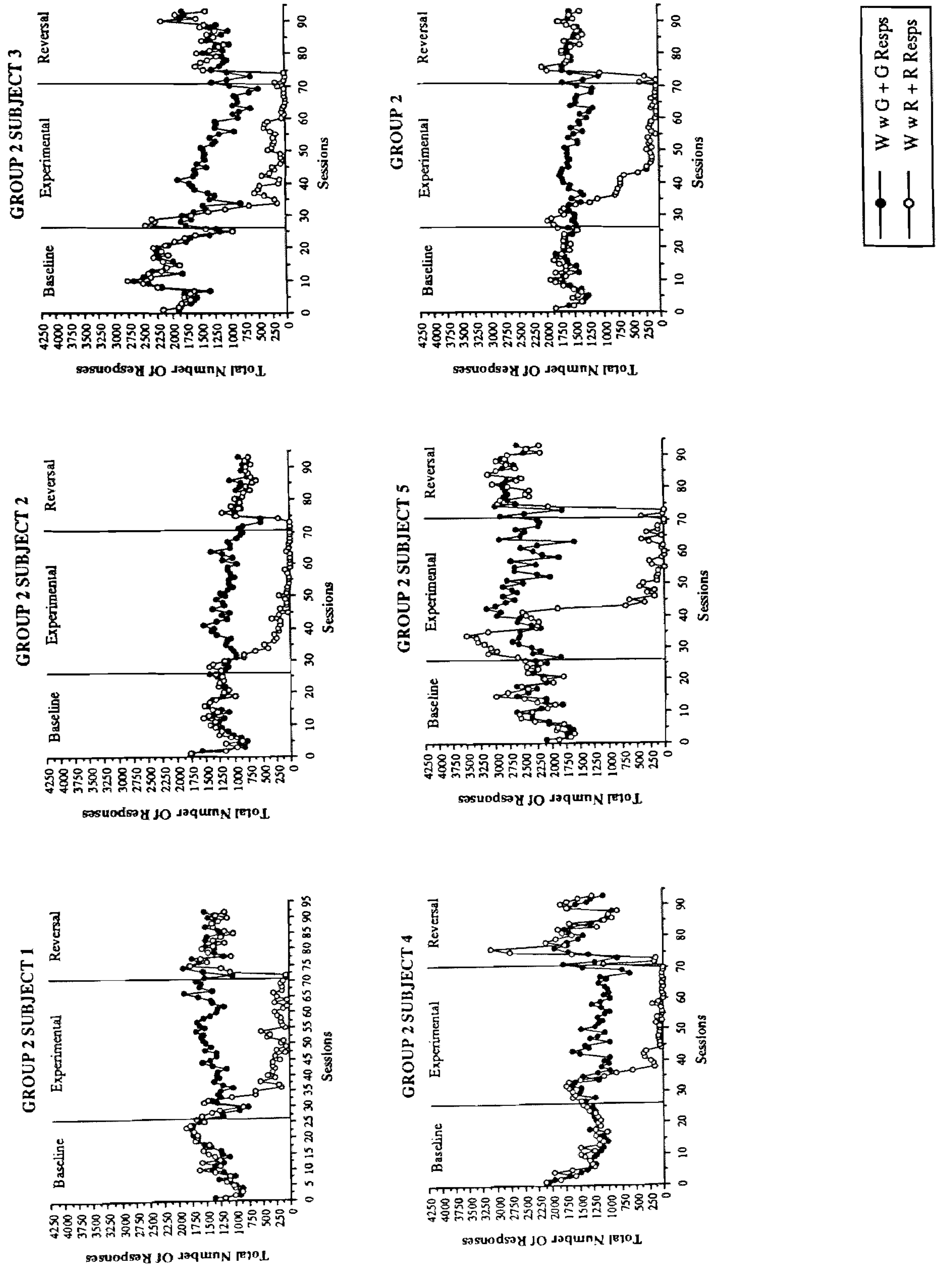

GROUP 2 SUBJECT 1
GROUP 2 SUBJECT 2
GROUP 2 SUBJECT 3
GROUP 2 SUBJECT 4
GROUP 2 SUBJECT 5
GROUP 2
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
W w G + G Resps
W w R + R Resps

Figure 5. The total number of responses across sessions for individual subjects in Group 2. The open circles show responses to the white operant key in the presence of a green signal key. The open diamonds show responses to the green signal key. The darkened squares show responses to the white operant key in the presence of a red signal key. The darkened diamonds show responses to the red signal key. The solid, vertical lines show the point at which the baseline phase changed to the experimental phase and the experimental phase changed to the reversal phase.

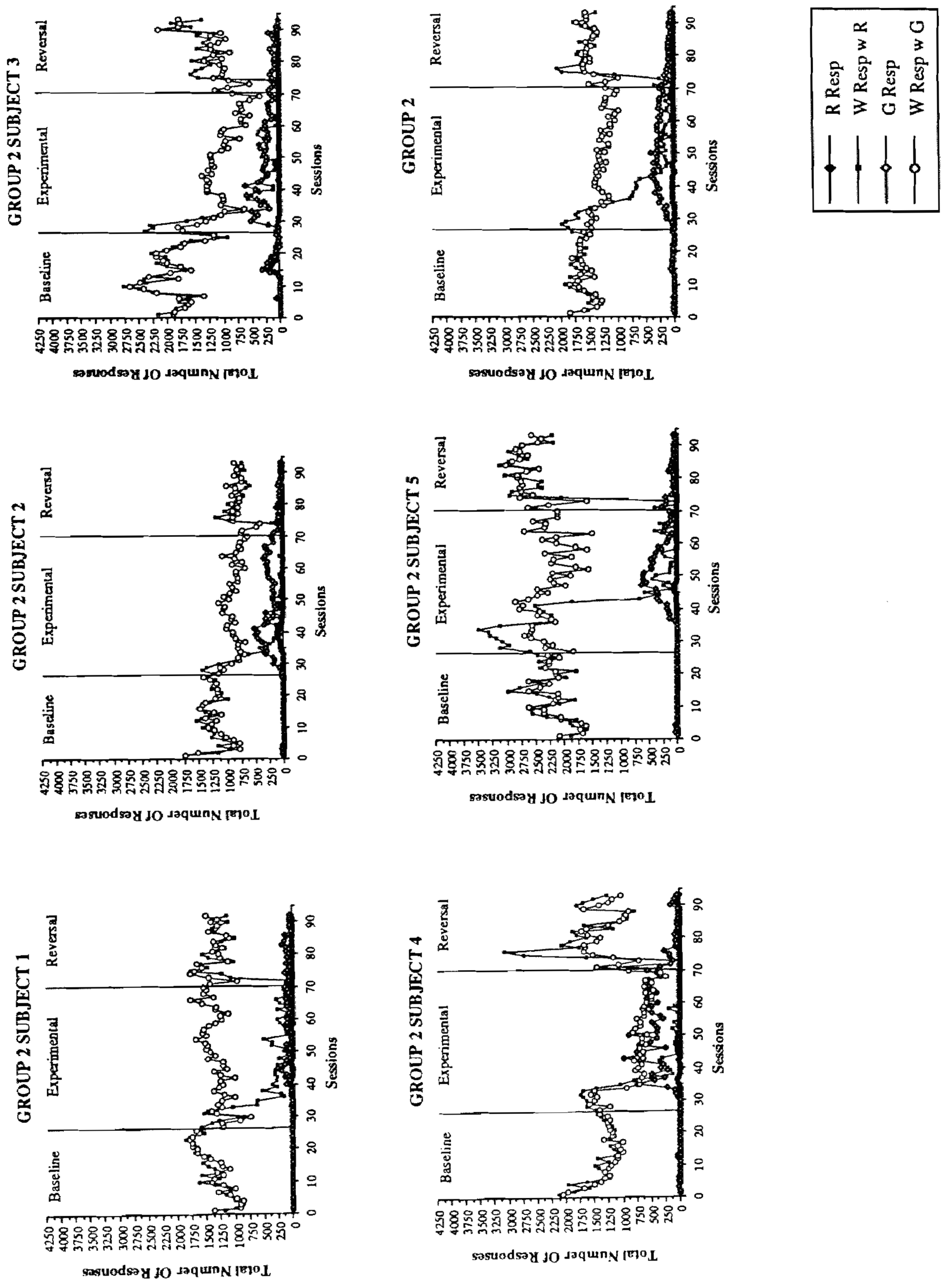

GROUP 2 SUBJECT 1
GROUP 2 SUBJECT 2
GROUP 2 SUBJECT 3
GROUP 2 SUBJECT 4
GROUP 2 SUBJECT 5
GROUP 2
Baseline
Experimental
Reversal
Sessions
Total Number Of Responses
R Resp
W Resp w R
G Resp
W Resp w G

Figure 6. The total number of responses across sessions for individual subjects in Group 3. The darkened circles show responses to the green operant key in the presence of a white alternative key summed with responses to the white alternative key. The empty circles show responses to the red operant key in the presence of a white alternative key summed with responses to the white alternative key. The solid, vertical lines show the point at which the baseline phase changed to the experimental phase and the experimental phase changed to the reversal phase.

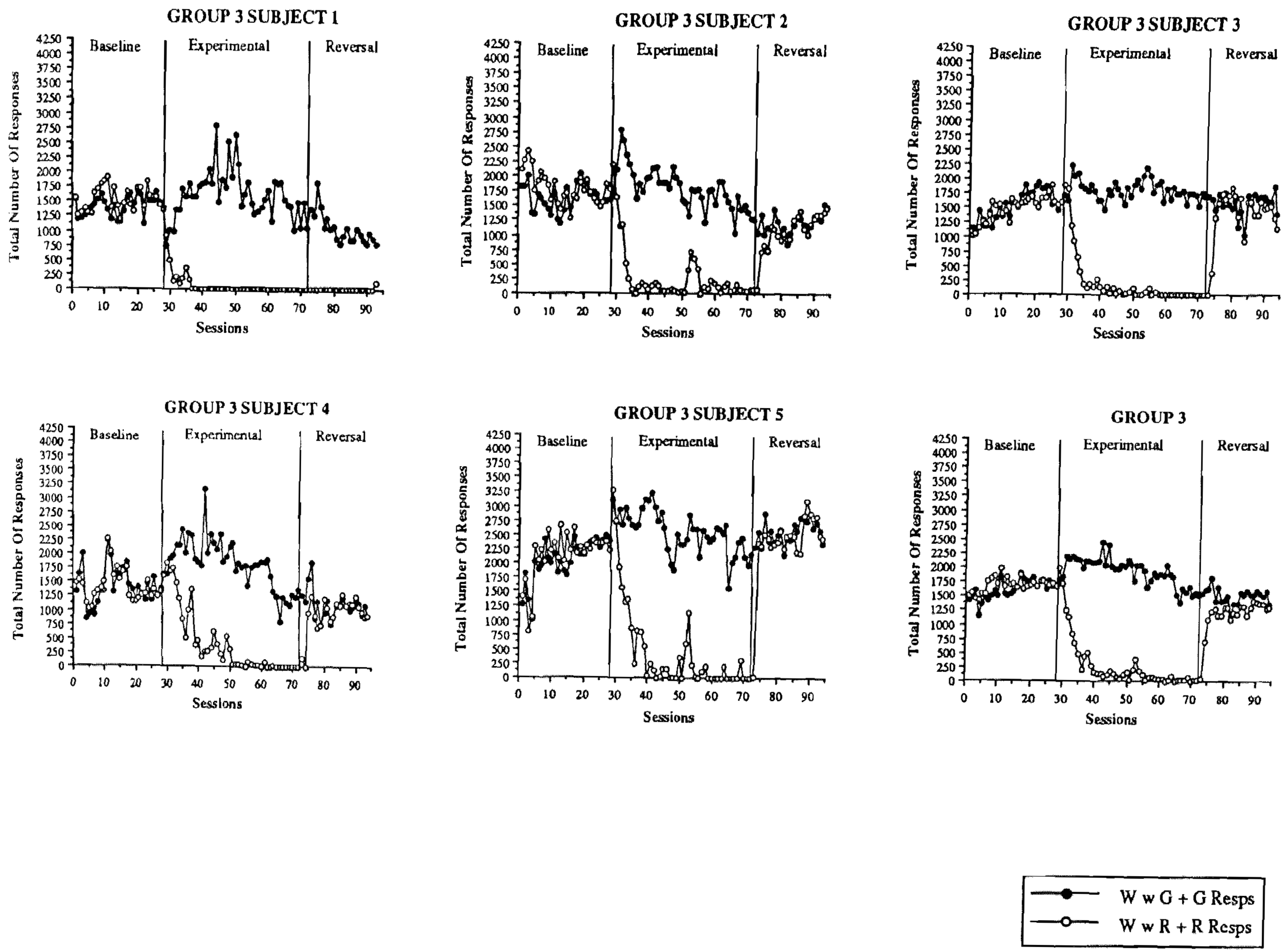

GROUP 3 SUBJECT 1
GROUP 3 SUBJECT 2
GROUP 3 SUBJECT 3
GROUP 3 SUBJECT 4
GROUP 3 SUBJECT 5
GROUP 3
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
W w G + G Resps
W w R + R Resps

Figure 7. The total number of responses across sessions for individual subjects in Group 3. The empty diamonds show responses to the green operant key in the presence of a white alternative key. The empty circles show responses to the white alternative key. The darkened diamonds show responses to the red operant key in the presence of a white alternative key. The darkened squares show responses to the white alternative key. The solid, vertical lines show the point at which the baseline phase changed to the experimental phase and the experimental phase changed to the reversal phase.

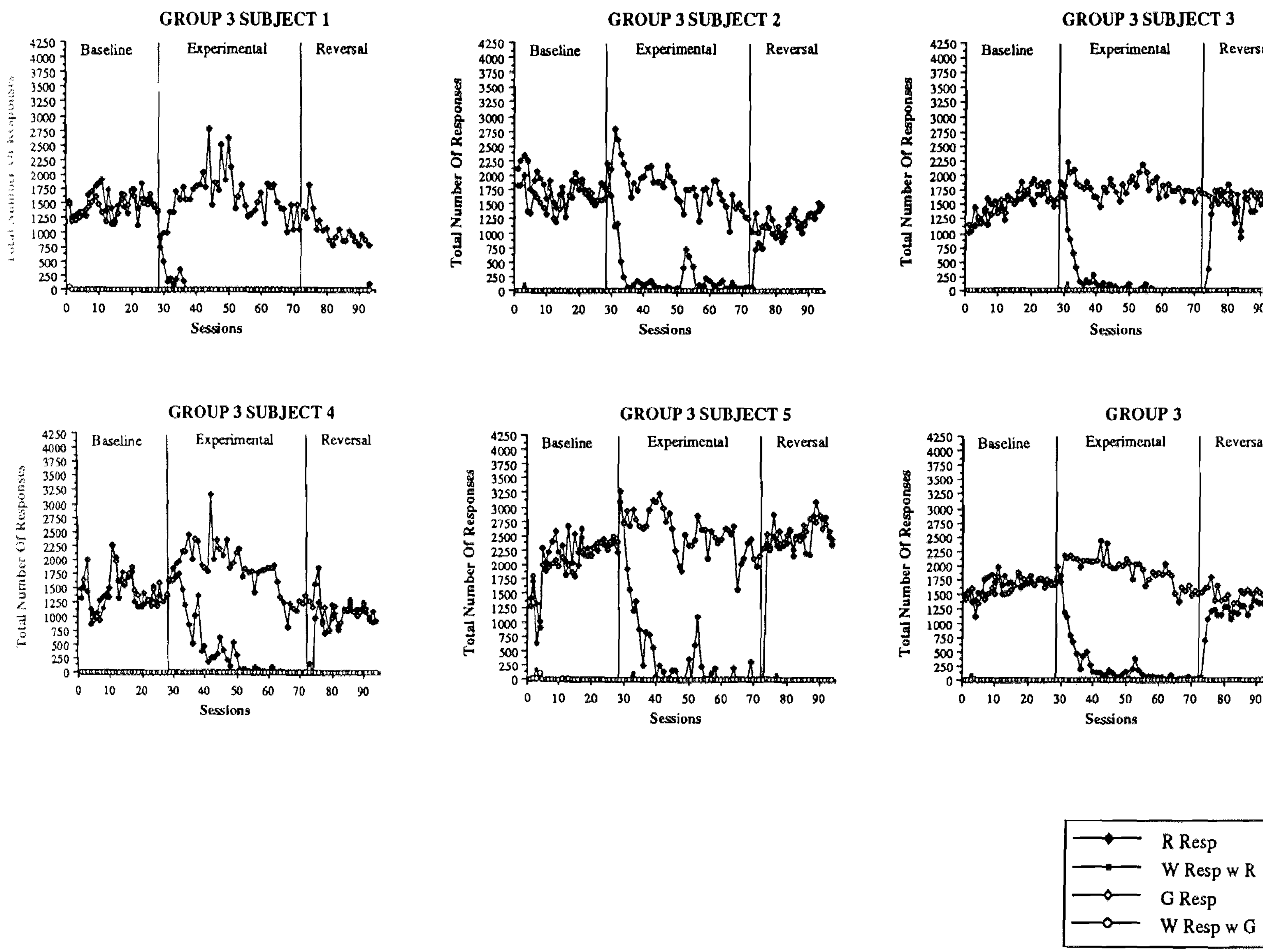

GROUP 3 SUBJECT 1
GROUP 3 SUBJECT 2
GROUP 3 SUBJECT 3
GROUP 3 SUBJECT 4
GROUP 3 SUBJECT 5
GROUP 3
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
R Resp
W Resp w R
G Resp
W Resp w G

Figure 8. The mean number of responses across sessions for Group 1, Group 2 and Group 3. The darkened circles show mean responses to the white operant key in the presence of a green signal key summed with mean responses to the green signal key for Groups 1 and 2. The empty circles show mean responses to the white operant key in the presence of a red signal key summed with mean responses to the red signal key for Groups 1 and 2. For Group 3, the darkened circles show mean responses to the green operant key in the presence of a white alternative key summed with mean responses to the white alternative key. The empty circles show mean responses to the red operant key in the presence of a white alternative key summed with mean responses to the white alternative key for Group 3. The solid, vertical lines show the point at which the baseline phase changed to the experimental phase and the experimental phase changed to the reversal phase.

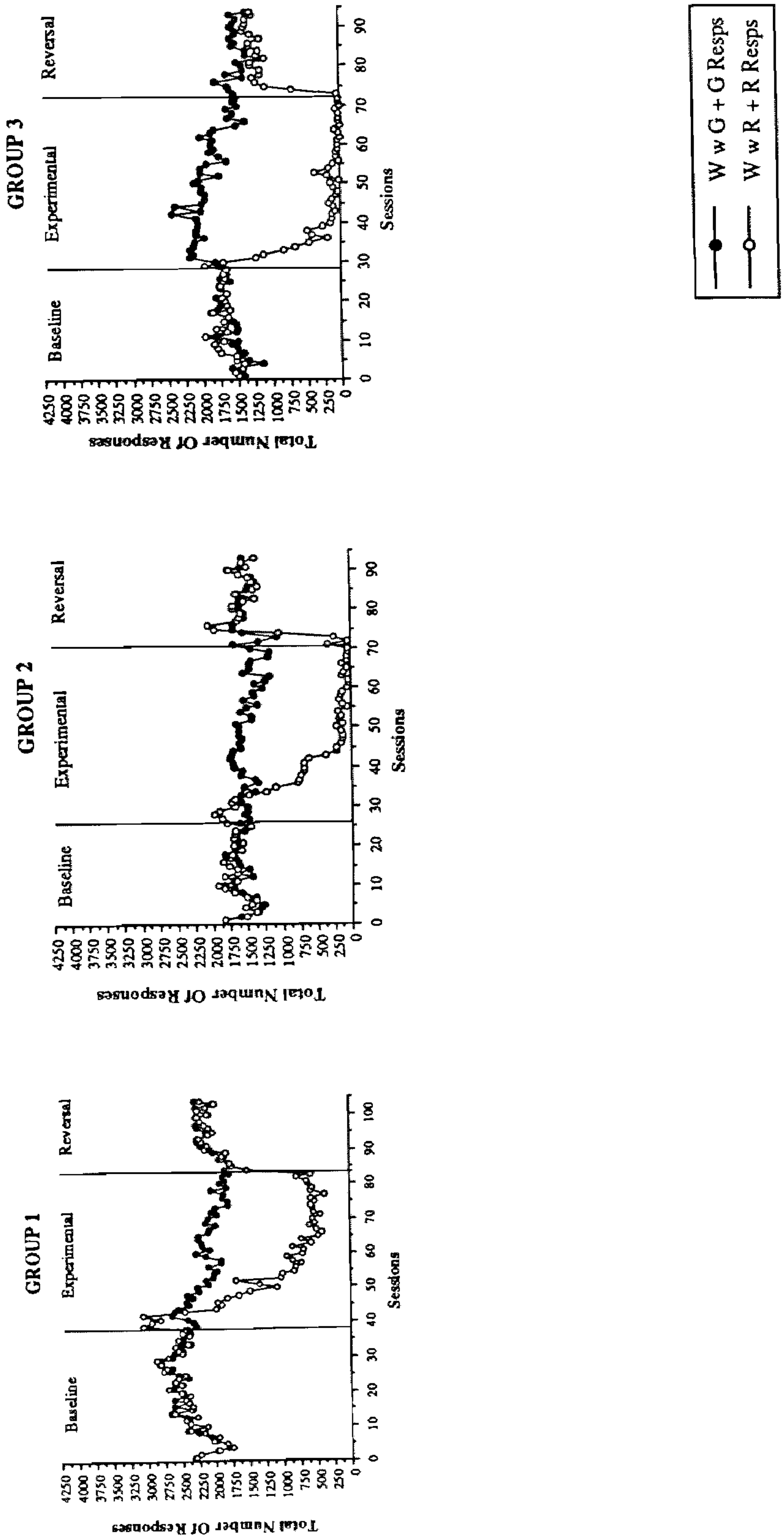

GROUP 1
GROUP 2
GROUP 3
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
W w G + G Resps
W w R + R Resps

Figure 9. The mean number of responses across sessions to the operant and signal keys Group 1 and Group 2 as well as to the operant and alternative keys for Group 3. The open circles show responses to the white operant key in the presence of a green signal key for Groups 1 and 2. The open diamonds show responses to the green signal key for Groups 1 and 2. The darkened squares show responses to the white operant key in the presence of a red signal key for Groups 1 and 2. The darkened diamonds show responses to the red signal key for Groups 1 and 2. The empty diamonds show responses to the green operant key in the presence of a white alternative key for Group 3. The empty circles show responses to the white alternative key in the presence of the green operant key for Group 3. The darkened diamonds show responses to the red operant key in the presence of a white alternative key for Group 3. The darkened squares show responses to the white alternative key in the presence of the red operant key for Group 3. The solid, vertical lines show the point at which the baseline phase changed to the experimental phase and the experimental phase changed to the reversal phase.

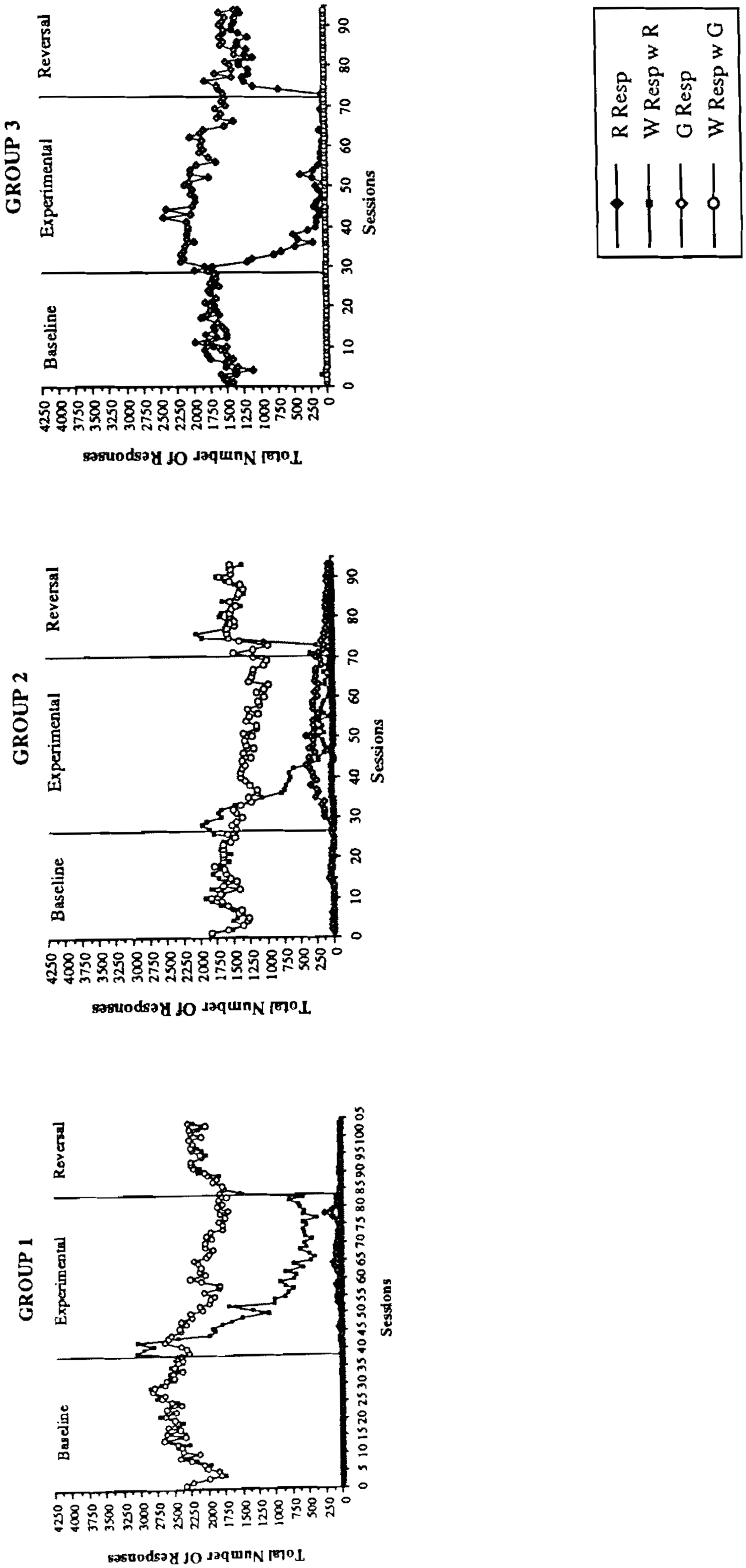

GROUP 1
GROUP 2
GROUP 3
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
R Resp
W Resp w R
G Resp
W Resp w G

Table 1

Mean Data for Group 1

Sessions	Phase	WwG + G	WwG+G Range	WwR+R	WwR+R Range	WwG	WwG Range	G	G Range	WwR	WwR Range	R	R Range
1 - 5	B	2048	1822 - 2329	2025	1763 - 2312	2046	1816 - 2328	2	0 - 6	2023	1759 - 2310	2	0 - 4
6 - 10	B	2181	2009 - 2428	2148	1975 - 2385	2180	2007 - 2426	1	0 - 2	2147	1975 - 2384	1	0 - 4
11- 15	B	2449	2345 - 2656	2425	2285 - 2625	2447	2345 - 2655	1	0 - 2	2424	2284 - 2625	1	0 - 4
16 - 20	B	2520	2409 - 2623	2420	2334 - 2518	2520	2409 - 2623	0	0 - 1	2420	2334 - 2518	0	0 - 0
21 - 25	B	2540	2407 - 2641	2564	2459 - 2709	2540	2407 - 2641	0	0 - 1	2564	2458 - 2709	0	0 - 2
26 - 30	B	2718	2635 - 2825	2771	2696 - 2867	2717	2635 - 2825	1	0 - 5	2770	2695 - 2865	1	0 - 3
31 - 35	B	2504	2376 - 2626	2523	2412 - 2586	2503	2375 - 2626	1	0 - 1	2523	2412 - 2585	0	0 - 0
36 - 38	B	2405	2368 - 2439	2444	2384 - 2495	2404	2367 - 2439	1	0 - 1	2444	2384 - 2495	0	0 - 0
39 - 43	E	2447	2283 - 2637	2858	2454 - 3050	2445	2282 - 2637	3	0 - 11	2853	2444 - 3050	4	0 - 11
44 - 48	E	2419	2319 - 2544	1867	1657 - 1982	2415	2311 - 2540	4	0 - 7	1849	1654 - 1972	17	4 - 34
49 - 53	E	2154	2039 - 2267	1330	1017 - 1700	2153	1976 - 2261	104	3 - 63	6618	1001 - 1695	33	3 - 17
54 - 58	E	1977	1901 - 2102	853	741 - 1014	1913	1822 - 2052	64	50 - 78	847	734 - 998	6	1 - 16
59 - 63	E	2179	2083 - 2288	760	590 - 937	2122	2038 - 2262	56	26 - 108	756	588 - 933	4	2 - 8
64 - 68	E	2129	1987 - 2251	543	414 - 724	2044	1910 - 2189	85	62 - 117	542	413 - 722	1	0 - 3
69 - 73	E	2049	1973 - 2133	528	434 - 569	1994	1925 - 2044	55	35 - 91	527	434 - 568	1	0 - 1
74 - 78	E	1878	1799 - 2045	534	373 - 596	1787	1742 - 1837	92	30 - 232	531	370 - 594	3	2 - 3
79 - 83	E	1846	1776 - 1917	649	574 - 795	1775	1686 - 1854	71	52 - 132	648	571 - 794	2	0 - 3
84 - 88	R	1831	1767 - 1930	1755	1505 - 1884	1820	1753 - 1921	11	5 - 19	1775	1505 - 1883	0	0 - 1
89 - 93	R	2148	2009 - 2248	2197	1815 - 2209	2138	1995 - 2245	10	3 - 18	2085	1815 - 2209	0	0 - 1
94 - 98	R	2174	2085 - 2251	2100	2017 - 2206	2170	2084 - 2245	5	1 - 9	2100	2017 - 2206	0	0 - 0
99 - 103	R	2170	2012 - 2264	2133	1989 - 2240	2168	2011 - 2261	2	0 - 4	2133	1989 - 2240	0	0 - 0
104	R	2272	2272 - 2272	2202	2202 - 2202	2272	2272 - 2272	1	1 - 1	2202	2202 - 2202	0	0 - 0

Table 2

Mean Data for Group 2

Sessions	Phase	WwG + G	WwG+G Range	WwR+R	WwR+R Range	WwG	WwG Range	G	G Range	WwR	WwR Range	R	R Range
1 - 5	B	1487	1284 - 1838	1552	1388 - 1833	1477	1282 - 1833	10	2 - 17	1546	1381 - 1831	6	3 - 13
6 - 10	B	1598	1404 - 1847	1683	1400 - 1941	1597	1403 - 1846	1	0 - 2	1679	1382 - 1941	4	0 - 18
11- 15	B	1578	1429 - 1701	1723	1655 - 1845	1557	1427 - 1700	22	1 - 65	1708	1635 - 1836	15	1 - 37
16 - 20	B	1708	1652 - 1840	1726	1600 - 1857	1677	1608 - 1802	31	12 - 44	1701	1569 - 1823	25	11 - 34
21 - 25	B	1610	1495 - 1679	1622	1460 - 1715	1606	1493 - 1666	4	1 - 13	1613	1457 - 1703	9	3 - 13
26	B	1611	1611 - 1611	1809	1809 - 1809	1593	1593 - 1593	18	18 - 18	1798	1798 - 1798	12	12 - 12
27 - 31	E	1533	1482 - 1602	1838	1683 - 1982	1462	1374 - 1532	71	10 - 142	1830	1678 - 1972	8	5 - 11
32 - 36	E	1503	1360 - 1631	1262	792 - 1692	1313	1139 - 1506	190	125 - 280	1253	777 - 1688	9	3 - 15
37 - 41	E	1595	1395 - 1714	717	689 - 762	1306	1153 - 1391	289	242 - 337	696	659 - 743	21	16 - 30
42 - 46	E	1681	1592 - 1748	328	160 - 627	1332	1238 - 1378	349	271 - 405	315	143 - 610	13	10 - 17
47 - 51	E	1611	1564 - 1656	154	128 - 226	1283	1199 - 1360	328	289 - 395	148	112 - 224	6	2 - 17
52 - 56	E	1461	1351 - 1592	146	61 - 198	1197	1120 - 1295	264	231 - 297	145	60 - 197	1	0 - 2
57 - 61	E	1412	1278 - 1559	116	37 - 179	1137	1042 - 1272	275	236 - 297	114	37 - 174	2	0 - 5
62 - 66	E	1372	1164 - 1541	92	35 - 132	1134	964 - 1270	237	200 - 271	91	34 - 130	2	1 - 3
67 - 70	E	1342	1175 - 1453	68	36 - 132	1109	994 - 1200	205	159 - 242	50	35 - 57	1	0 - 3
71 - 75	R	1457	1059 - 1679	729	55 - 1962	1315	957 - 1562	142	102 - 205	728	55 - 1960	1	0 - 2
76 - 80	R	1598	1524 - 1685	1707	1578 - 2040	1520	1452 - 1573	78	52 - 112	1705	1578 - 2039	2	1 - 3
81 - 85	R	1561	1482 - 1621	1522	1370 - 1676	1482	1415 - 1534	79	66 - 92	1520	1368 - 1675	2	1 - 3
86 - 90	R	1522	1377 - 1751	1506	1328 - 1728	1465	1332 - 1692	57	45 - 66	1501	1327 - 1723	5	0 - 9
91 - 93	R	1555	1543 - 1565	1470	1361 - 1559	1514	1506 - 1521	40	35 - 49	1464	1356 - 1553	6	5 - 6

Table 3

Mean Data for Group 3

Sessions	Phase	WwG + G	WwG+G Range	WwR +R	WwR+R Range	WwG	WwG Range	G	G Range	WwR	WwR Range	R	R Range
1 - 5	B	1410	1154 - 1602	1491	1411 - 1558	8	1 - 22	1402	1132 - 1597	20	0 - 79	1471	1369 - 1554
6 - 10	B	1503	1419 - 1602	1730	1537 - 1837	1	0 - 2	1502	1419 - 1601	0	0 - 1	1730	1536 - 1836
11- 15	B	1586	1507 - 1810	1773	1661 - 1980	2	0 - 4	1584	1503 - 1807	2	0 - 3	1772	1658 - 1977
16 - 20	B	1772	1652 - 1887	1698	1627 - 1864	1	0 - 2	1772	1650 - 1887	1	0 - 1	1697	1626 - 1863
21 - 25	B	1723	1610 - 1823	1731	1673 - 1763	1	0 - 1	1722	1609 - 1822	1	0 - 2	1729	1671 - 1762
26 - 28	B	1701	1657 - 1763	1686	1662 - 1700	1	0 - 2	1700	1657 - 1761	0	0 - 0	1686	1661 - 1700
29 - 33	E	2019	1777 - 2189	1373	821 - 1984	1	0 - 1	2018	1777 - 2189	13	0 - 32	1360	796 - 1984
34 - 37	E	2078	1969 - 2144	456	209 - 682	1	0 - 2	2077	1968 - 2144	1	0 - 2	455	208 - 679
38 - 43	E	2140	2028 - 2436	153	85 - 271	0	0 - 0	2140	2028 - 2436	1	0 - 2	152	84 - 269
44 - 48	E	2062	1948 - 2376	100	35 - 171	0	0 - 0	2062	1948 - 2376	0	0 - 1	100	35 - 170
49 - 53	E	1985	1743 - 2120	178	14 - 382	0	0 - 0	1985	1743 - 2120	1	0 - 6	177	14 - 377
54 - 58	E	1850	1644 - 2031	86	17 - 182	0	0 - 0	1850	1644 - 2031	0	0 - 0	86	17 - 182
59 - 63	E	1890	1821 - 2026	32	6 - 49	0	0 - 1	1889	1820 - 2026	0	0 - 1	32	6 - 49
64 - 68	E	1579	1372 - 1833	31	11 - 82	0	0 - 0	1579	1372 - 1832	0	0 - 0	31	10 - 82
69 - 72	R	1236	1477 - 1649	22	9 - 73	0	0 - 0	1235	1477 - 1649	0	0 - 0	22	9 - 73
73 - 77	R	1591	1393 - 1802	861	52 - 1249	1	0 - 6	1590	1393 - 1802	5	0 - 19	856	52 - 1230
78 - 82	R	1414	1148 - 1632	1185	1074 - 1278	0	0 - 0	1413	1148 - 1632	0	0 - 0	1185	1074 - 1278
83 - 87	R	1465	1349 - 1575	1225	1152 - 1307	0	0 - 0	1465	1349 - 1575	0	0 - 2	1224	1152 - 1307
88 - 92	R	1522	1485 - 1581	1351	1277 - 1403	0	0 - 0	1522	1485 - 1580	0	0 - 0	1351	1276 - 1403
93 - 94	R	1467	1360 - 1574	1264	1253 - 1275	0	0 - 0	1467	1360 - 1574	0	0 - 0	1264	1253 - 1275

key was uniform across all subjects for the first three to eight sessions. Negative induction was observed in Subjects 1 and 4. After an initial disruption, Subjects 2, 3 and 5 maintained baseline levels of responding to the operant key, which continued to be correlated with the variable-interval 1-minute schedule of reinforcement.

Figure 3 (also see Appendix C) presents the total number of responses to the operant and signal keys separately for Group 1. No responses were directed to the green or red signal keys by Subject 1. Virtually no responses were directed to the green or red signal keys by Subject 3. Subjects 2 and 4 emitted few responses to the green signal key and even fewer to the red signal key during the experimental phase. Subject 5 showed a peak and then a decline in responding to the green signal key during the second half of the experimental phase. Responses to both green and red signal keys for Subjects 2, 4 and 5 quickly diminished to zero or near zero with the reinstatement of baseline conditions in the reversal phase. Nearly complete recovery of the original baseline performances were seen for Subjects 2, 3 and 5.

Figure 4 (also see Appendix B) depicts the number of responses to the operant key summed with responses to the signal key for both component types across all sessions for each subject in Group 2. Group 2 results are also presented in Figures 4 and 5 to show group data are analogous to individual data. Similar results were obtained in Group 2 as with Group 1. Indeed, no positive behavioral contrast was observed for any of the five subjects in Group 2. Negative induction was noted, however, for all of the subjects in Group 2. As shown in Figure 5 (also see Appendix C), virtually no responses were emitted to the green or red signal keys during baseline for Subjects 1, 2, 4 and 5. Subject 3 showed a peak and then a decline toward zero in responding to the green and red signal keys during baseline. In comparison to subjects in other groups, subjects in Group 2 showed substantial responding to the green signal key during the experimental phase. Nevertheless, the summation of responses to the operant key and the signal key did not produce positive behavioral contrast. Responses to the green signal key persisted for every subject in Group 2 throughout the reversal phase. Despite intrasubject variability, Group 2 responding approached baseline performances in the reversal phase.

Figure 6 (also see Appendix B) depicts responses to the operant key summed with responses to the alternative key for both component types across all sessions for each subject in Group 3. Group 3 results are also presented in Figure 6 to show group data are also analogous to individual data. All subjects in Group 3 showed increased responding to the red key correlated with extinction for the first session in the experimental phase with decreased responding in subsequent sessions. Positive behavioral contrast was clearly observed in subjects 2, 3, 4 and 5. Positive behavioral contrast may be projected for Subject 1 as well. Responding to the operant key correlated with the variable-interval 1-minute schedule increased above baseline levels for Subject 1; and although the increase was not immediate, the effect was present.

Responses to the operant key and the alternative key for both component types for all five subjects in Group 3 are presented in Figure 7 (also see Appendix C). No responding to the alternative key was noted across all phases and subjects in Group 3. As compared to Groups 1 and 2, subjects in Group 3 displayed the least amount of variability in responding. Subjects 2, 3, 4 and 5 resumed responding at levels similar to baseline performances during the reversal phase. Subject 1 did not respond to the red key and, therefore, did not come into contact with reinstated contingencies until the ninety-third session of the reversal phase. For subject 1, responding rapidly increased to frequencies approaching baseline performance once the contingency was re-experienced.

Figures 8 and 9 (also see Appendices D and E) present results for comparisons across experimental groups. For Groups 1 and 2, Figure 8 (and Appendix D) shows mean responses to the operant key summed with mean responses to the signal key for both components. Figure 8, for Group 3, shows mean responses to the operant key summed with mean responses to the alternative key. Intergroup variability is evident in Figure 8 and Tables 1, 2 and 3. Group 1 mean baseline response rates ranged from 1,763 to 2,868 whereas Group 2 and Group 3 mean baseline response rates ranged from 1,284 to 1,941 and 1,154 to 1,980, respectively. Variability from session to session within Group 1 was equally distributed across both component types. At various points throughout the baseline, Groups 2 and 3 emitted more responses in the presence of the red stimulus than the green. As seen in Figure 9 (also see Appendix E), virtually no responses were emitted on the signal key for Groups 1 and 2 or the alternative key for Group 3 in the baseline phase.

Immediate substantial increases in responding to the operant key correlated with extinction were noted at the onset of the experimental phase for all groups (see Figure 9). Initial increases were well above baseline and operant key responses in unchanged components for all groups. Increases in responding, with the initiation of the experimental phase, were maintained for the first four sessions for Group 1; the first six sessions for Group 2; but only the first session for Group 3. This extinction burst disappeared for Groups 1, 2 and 3 with the fifth, seventh and second sessions, respectively.

The absence of a positive behavioral contrast effect was clear, in Figures 8 and 9, for Groups 1 and 2. Summing the mean responses across the operant and signal keys for Groups 1 and 2 (see Figure 8) also did not result in positive behavioral contrast. In fact, a negative induction effect was observed for Groups 1 and 2 following the extinction burst in initial sessions of the experimental phase. Positive behavioral contrast was observed, however, in Group 3 as shown in Figures 8 and 9. In the experimental phase, decreased responding to the operant key correlated with extinction was more pronounced in Groups 2 and 3 than in Group 1.

Mean responses to the operant, signal and/or alternative keys are presented separately in Figure 9 (also see Appendix C) for all groups. As shown in Figure 9, pecking directed at the signal key did not occur with the onset of the experimental phase for Groups 1 and 2. For Group 1, mean responses to the green signal key were observed after the fifty-third session (or fifteen sessions into the experimental phase) and continued throughout this phase. Substantial mean responses to the green signal key, for Group 2, were observed after the twenty-eighth session (or two sessions into the experimental phase) and continued throughout the experimental and reversal phases. As noted in Figure 9, as the reversal phase continued, mean responses to the green signal key decreased to near zero levels for Group 2. Group 3 showed virtually no responding to the alternative key throughout all phases of the experiment.

For Groups 1 and 2, reinstatement of baseline conditions in the reversal phase produced a substantial recovery of original baseline performances (see Figures 8 and 9). In Group 3, recovery of responding to the operant key previously correlated with extinction in the experimental phase was not as complete as in the other two groups.

CHAPTER IV

Discussion

The present research was designed to replicate Keller's (1974) first experiment to clarify his previously ambiguous findings and investigate the stimulus conditions required to produce positive behavioral contrast. Pigeons were trained to key peck in a two-key procedure and stimulus conditions were manipulated across three experimental groups. The pigeons in Group 1 were exposed to procedures replicating Keller's (1974) traditional two-key procedure in which the white, center key served as the operandum and the other key signaled scheduled consequences. In Group 2, pigeons experienced a two-key procedure in which the white key served as an operandum and the other key signaled scheduled as in Group 1; however, the position of the keys alternated in a pseudo-random order. Finally, Group 3 pigeons experienced a two-key procedure in which the key which served as the operandum also signaled scheduled consequences and alternated pseudo-randomly with the other key which had no signal properties or scheduled consequences.

Data for all three experimental groups clearly failed to support an additivity account of contrast. First, no positive behavioral contrast was observed in Group 1, where Keller's (1974) traditional signal-key procedure was used. There was virtually no signal-key pecking in four of five subjects in Group 1. One subject, however, showed a small peak and then a decline in responding to the green signal key in the latter half of the experimental phase. The contributions of the putative "classical pecks" (as identified in Keller's scheme) were insignificant, and did not result in a contrast effect. All subjects in Group 2 (where the modified two-key procedure was used), showed signal-key pecking several sessions into the experimental phase. Nevertheless, no positive behavioral contrast was observed in Group 2 whether operant key, or operant key plus signal-key response totals were used as a criterion. Third, positive behavioral contrast was observed with essentially no alternative key pecking for all subjects in Group 3.

These findings are inconsistent with Keller's findings and projections. Keller used the two-key signal procedure to present stimuli in a location different from the operandum. To Keller, presenting stimuli on the operandum produced an experimental confound that would not allow researchers to differentiate operant (response-reinforcer contingencies) and classical influences (stimulus-reinforcer contingencies). Keller maintained that stimulus control could be achieved regardless of the location of the discriminative stimuli in relation to the operandum. Group 1, in the present experiment, was intended to be a direct replication of Keller's methodology. Although Keller reported no consistent results, he was able to see positive behavioral contrast in some animals under certain conditions. Group 1 was intended to be a direct replication of Keller's methodology, yet no hint of positive behavioral contrast was noted. No positive behavioral contrast was observed in Group 1 whether responses to the operant key or responses to the signal-key were summed or considered in isolation. Other researchers have had difficulty in replicating Keller's findings (Schwartz, 1975; Spealman, 1976; Woodruff, 1979). When Keller moved discriminative stimuli off of the operant (response) key, positive behavioral contrast was not reliably produced.

When stimulus and response keys were separated, in this experiment, no behavioral contrast was observed. When stimuli were projected onto the operandum, as with Group 3, positive behavioral contrast was easily obtained. This experimental confound, therefore, seems to be a crucial factor in the production of positive behavioral contrast which was consistent with the empirical and theoretical findings of Hearst and Gormley (1976) and Williams and Heyneman (1981).

Based on Keller's projections, the manipulations used with Groups 1 and 2 should have produced similar, if not identical, response patterns. This was not the case. Baseline frequencies were generally lower (also noted by Williams, 1983) when the locations of the stimulus/operandum varied, as compared to when the operant key was stationary. This is not surprising given that one group of birds needed only to stand in front of one key and peck when the experimental chamber was illuminated, while the other group had to first locate the operant key before directing responses. In addition to limiting the speed of the response at the onset of the component, the variation in location of the operandum imposed the necessity for vigilance--or increased attention in the organism. Such vigilance was also necessitated by the stimulus arrangement in Group 3 - again, due to alternation in the location of the operandum. Such attentional effects do not directly account for the evolution of the contrast phenomenon, however, the same level of attentional demand in Groups 2 and 3 produced differing levels of contrast.

The experimental phase introduced the same discrimination for all three groups (green, reinforced; red, not reinforced): However, the present paradigm produced variation in availability of the discriminative stimuli to the subject. In Group 3, the operandum provided meaningful information because discriminative stimuli were located there. Groups 1 and 2, however, experienced discriminative stimuli on the other key. Stimuli which are projected on the operandum, as with Group 3, should be more salient than stimuli located off the operandum, as with Groups 1 and 2. Only when vigilance was reinforced in baseline and the stimuli associated with the operandum were salient in the experimental phase, was positive behavioral contrast produced, as with Group 3.

Some attention to stimuli may very well have been maintained during baseline for Group 2 where operant key position varied. If attention to stimuli was maintained by this manipulation, then clearly more than simple attentional mechanism is necessary to operant key and the stimulus on the operant key was the point of concentration rather than a lighted key containing irrelevant stimuli for Group 3. Clearly if attention to stimuli during baseline is necessary then the experimental manipulation used with Group 2 either: 1) did not maintain attention or; 2) did not maintain enough attention to produce contrast.

One could argue that the findings in the present experiment were a product of stimulus control; that is, stimuli presented to Groups 1 and 2 were nonsalient and did not serve as discriminative stimuli. Therefore, the stimulus-reinforcer contingencies that are normally in effect during discrimination training (for example, a change from a multiple variable-interval variable-interval to a multiple variable-interval extinction) were not present for Groups 1 and 2. Previous research using the signal-key procedure has produced inconsistent results. An inference may be made that in the studies that produced signal-key pecking the stimuli were salient and in the studies failing to produce signal-key pecking were nonsalient. The placement of stimuli on the response key, for Group 3, was intended to bring salience to the stimuli (i.e. stimulus control) and hence produced positive behavioral contrast. In Keller's (1974) second experiment, the alternation of a two-key signal procedure and a one-key procedure made the stimuli relevant because during half of the experimental sessions the stimuli were presented on the response key. Keller's signal-key procedure appears to separate the stimulus-reinforcer contingencies and response-reinforcer contingencies, but this procedure may not effect stimulus control. The present discussion of the possible changes in stimulus control has serious theoretical implications for interpreting the results of other signal-key procedures. Many conclusions and the basis for theoretical explanations have been drawn from such research. Future research should show empirical evidence of discrimination and stimulus control.

These data did not support the emotionality hypothesis (or the response reduction explanation) of positive behavioral contrast. Positive behavioral contrast occurred in the Group 3, the group projected to have the least difficult discrimination. Positive behavioral contrast did not occur in Group 1 or Group 2 where the discriminations were projected to have an intermediate difficulty and the most difficulty, respectively. Moreover, no interim behavior in the form of responding to the alternative, irrelevant key ever occurred for Group 3. There was an extinction burst for each group which did not correspond with the projected difficulty of the discrimination for each group. The largest extinction burst was observed in Group 1. In Group 2, the next largest extinction burst was observed. Group 3 showed the smallest extinction burst which consisted of only the first session of the experimental phase.

Extinction bursts are considered a by-product of emotionality associated with the introduction of extinction. Extinction bursts are evidence of emotionality. Emotionality was displayed as extinction bursts in all groups, but neither equally nor in the form of positive behavioral contrast. In fact, positive behavioral contrast was inversely related to the occurrence of extinction bursts. Emotionality, therefore, is inversely related to positive behavioral contrast. There was evidence to suggest that the degree of reactivity was a direct effect of the respective experimental manipulations. Specifically, reactivity was negatively associated with the degree to which discriminative stimuli were recognized as such. The greatest extinction bursts (emotionality) were seen in Group 1, where discriminative stimuli were functionally irrelevant in baseline. Hence, attending to the red/green variation was not well defined in these animals' repertoires. Emotionality was less evident in Group 2 in which, while irrelevant during baseline, the red/green variation was regularly experienced as a necessary condition for locating the more meaningful white stimulus. As the animals in Group 2 entered the experimental phase, therefore, they had greater experience with the red/green variation and were consequently better prepared to learn that discrimination. Finally, the least emotionality was evidenced by Group 3 subjects. Their "experience" of red/green variation was requisite for successful responding during baseline (i.e., Group 2 subjects could correctly respond to white, or not respond to red/green; Group 3 could only successfully respond to red/green).

The extinction burst as a manifestation of emotionality is inconsistent with Terrace's (1963a, 1963b, 1966a, 1966b, 1972) account of positive behavioral contrast as an emotional by-product. Not only did the most difficult discrimination produce the least "frustration" effect, but Terrace's errorless learning would have clearly eliminated such reactivity. Thus, the extinction burst and positive behavioral contrast are different phenomena. Terrace's procedure may not have addressed the behavioral contrast issue.

The present experimental paradigm did not address the reinforcement frequency explanation of positive behavioral contrast. Reinforcement frequency was perfectly confounded with all other variables manipulated in the experiment.

The present experiment was also pertinent to the induction explanation. If informative stimuli do produce excitation, as suggested in the introduction, then the induction hypothesis would be supported by these data. However, in the interest of parsimony, and in light of the informative-vigilance hypothesis outlined above, it may be unnecessary to introduce the concept of excitation to explain positive behavioral contrast.

The findings in the present experiment suggest that subsequent research is necessary to assess the impact of several variables on the behavioral contrast phenomenon. First, a replication of the current study employing a changeover delay (COD) would determine whether signal-key pecking observed in Group 2 was a by-product of generalization or constituted adventitious reinforcement. Second, a fourth experimental group should be considered in comparison to the three experimental groups in the current procedure. In order to assess attentional factors and the salience of stimuli, for this fourth group signaled consequences should be projected on the stationary operandum. Finally, additional studies should be proposed utilizing generalization gradients to assess the informational value of discriminative stimuli.

The present procedure was consistent with a number of researcher's conclusions (i.e., Schwartz & Gamzu, 1977; Williams, 1979; Williams, 1983; Williams & Heyneman, 1981) showing that additivity theory as well as other previous theories of contrast cannot adequately account for positive behavioral contrast in multiple schedules of reinforcement. The current procedure shows that positive behavioral contrast is not a universal finding with Keller's signal-key procedure. The present results go beyond previous findings, however, suggesting two alternative mechanisms that may serve as crucial factors in the formation of the positive behavioral contrast phenomenon. In light of the present data, both attentional factors during the baseline phase and the salience of stimuli during the experimental phase are significant variables in the production of positive behavioral contrast. The implication is that another explanation of behavioral interactions may account for the phenomenon. The informative-vigilance account of positive behavioral contrast should be evinced by further investigations.

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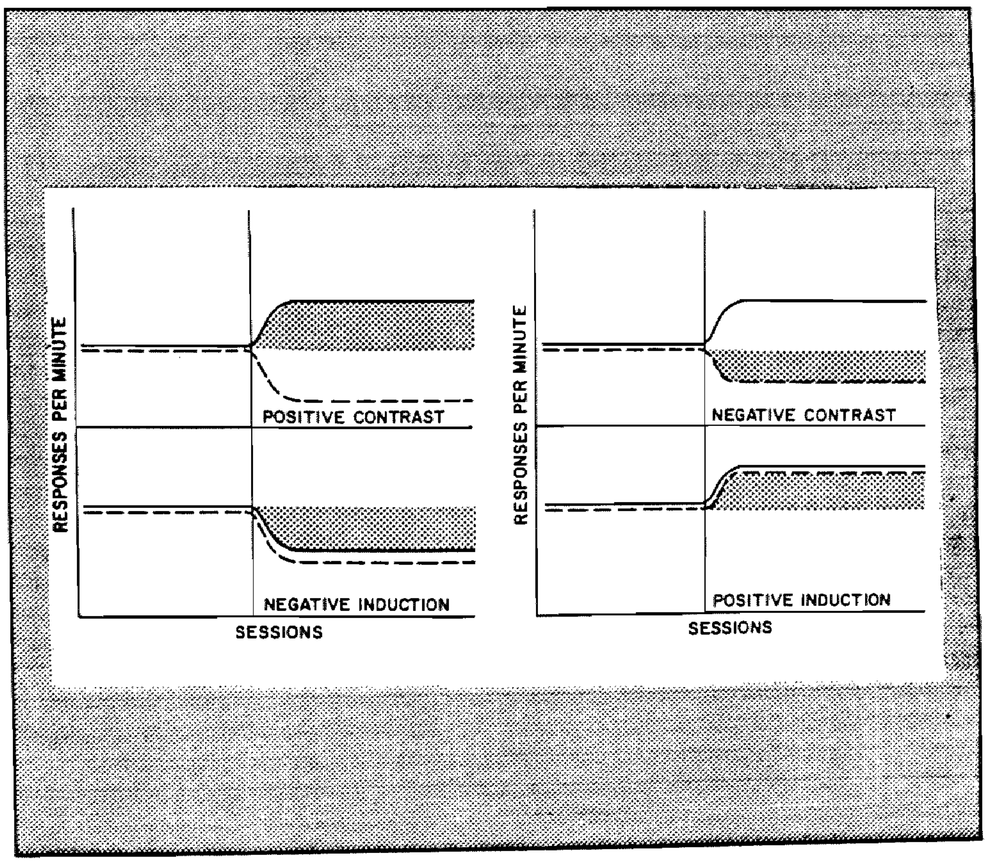
Appendix A

Schematic Diagrams of the Four Types of Behavioral Interaction

Figure 10. Schematic diagrams of the four types of behavioral interactions: positive contrast, negative contrast, positive induction and negative induction from "Pavlovian Control of Operant Behavior" by B. Schwartz and E. Gamuz in W. K. Honig & J. E. R. Stadddon (Eds), Handbook of Operant Behavior, 1977, p. 72. Reprinted by permission of Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

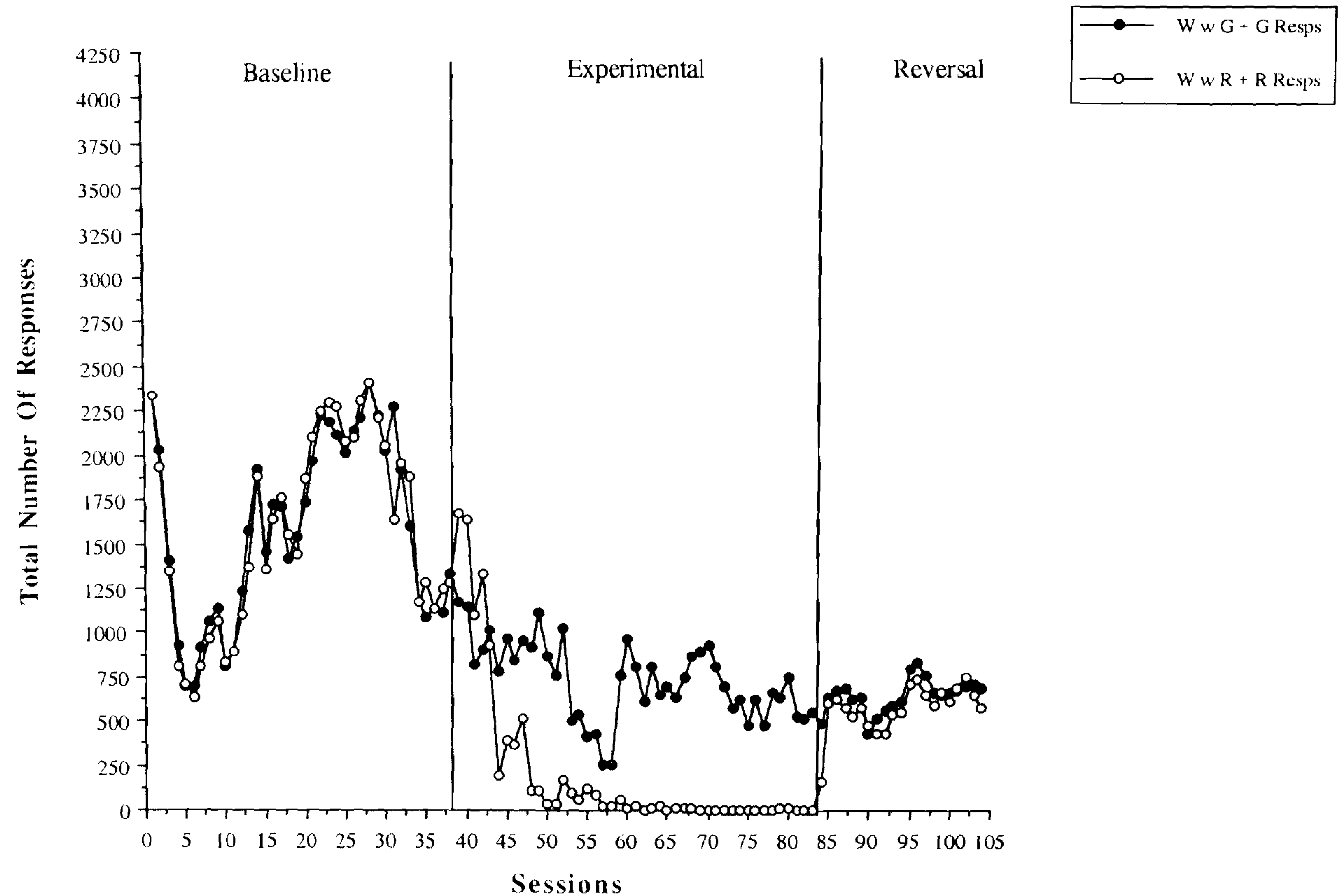


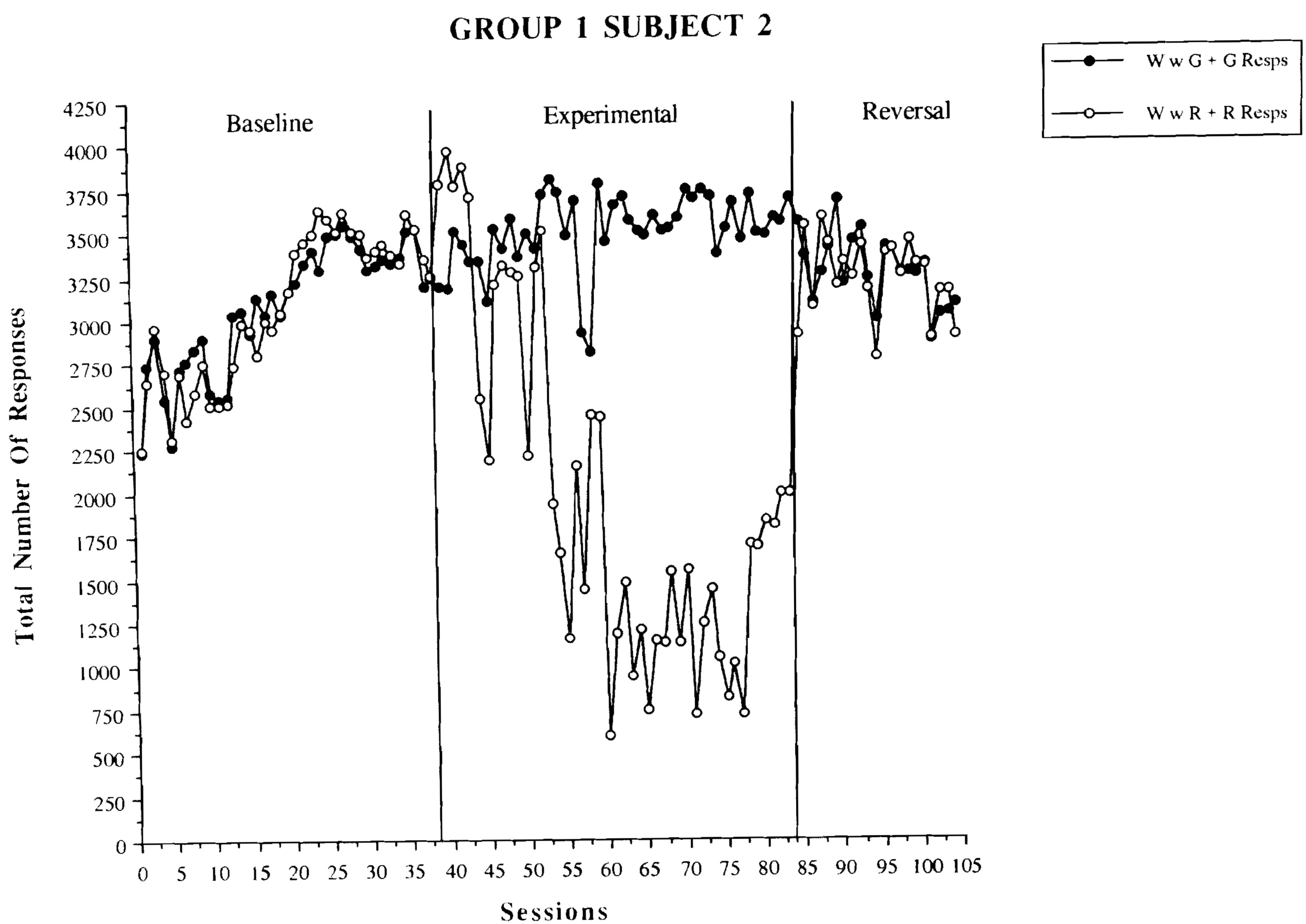
RESPONSES PER MINUTE
POSITIVE CONTRAST
NEGATIVE INDUCTION
SESSIONS
RESPONSES PER MINUTE
NEGATIVE CONTRAST
POSITIVE INDUCTION
SESSIONS

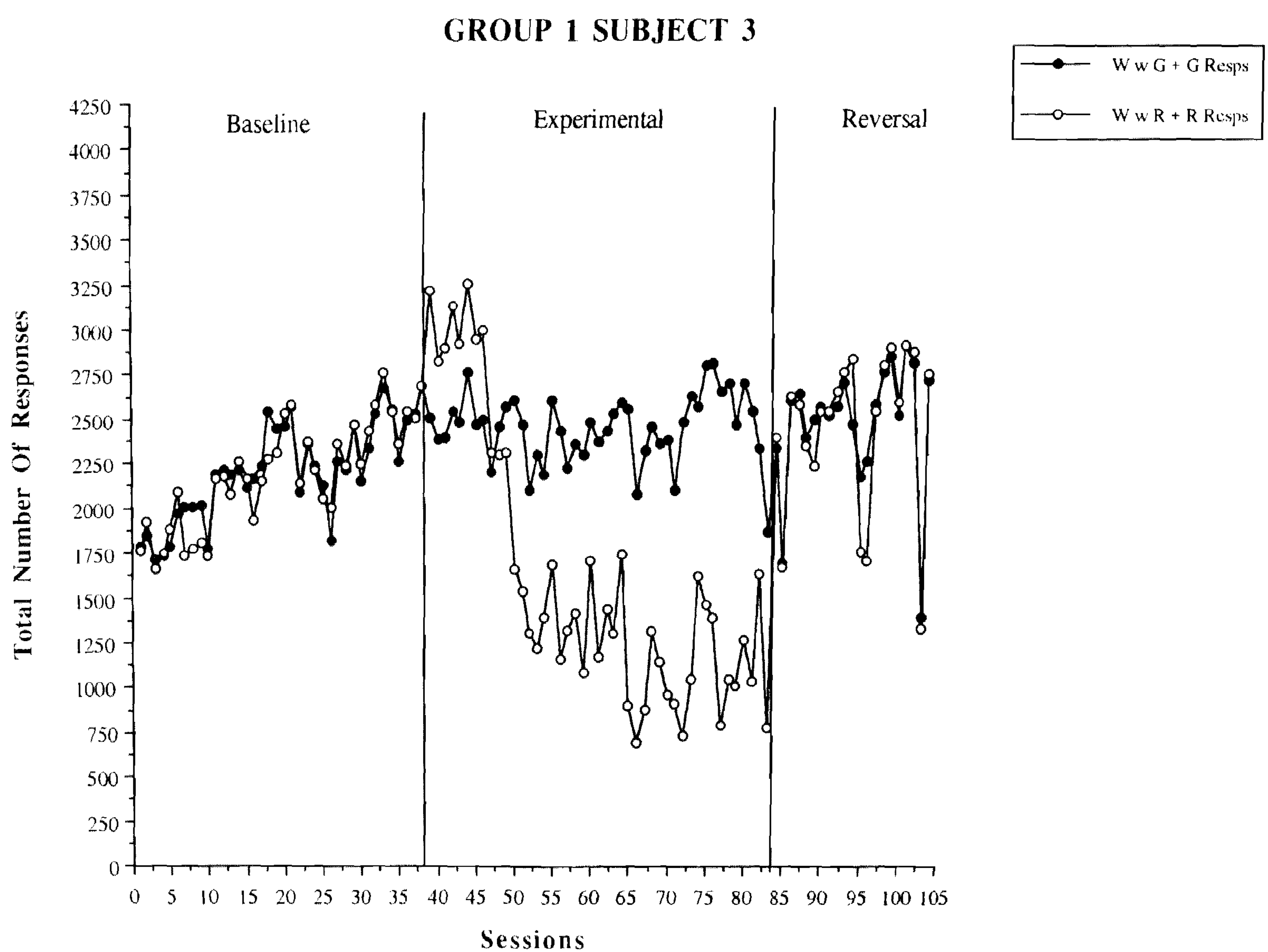
Appendix B

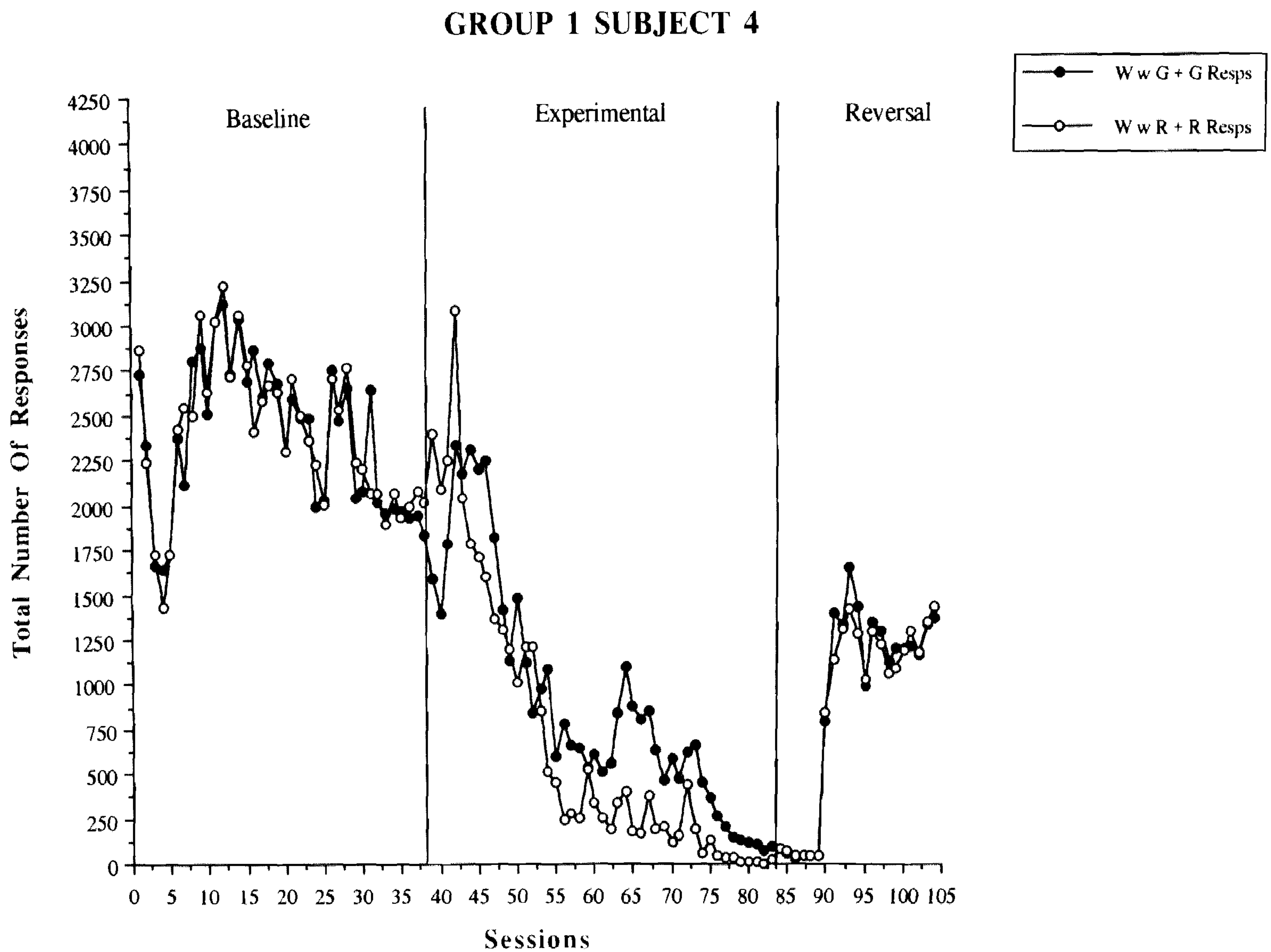
Figures Depicting the Performance of Each Subject with Responses to Operant Key Summed with Responses to Signal Key or Responses to Alternative Key for Each Component Type

GROUP 1 SUBJECT 1

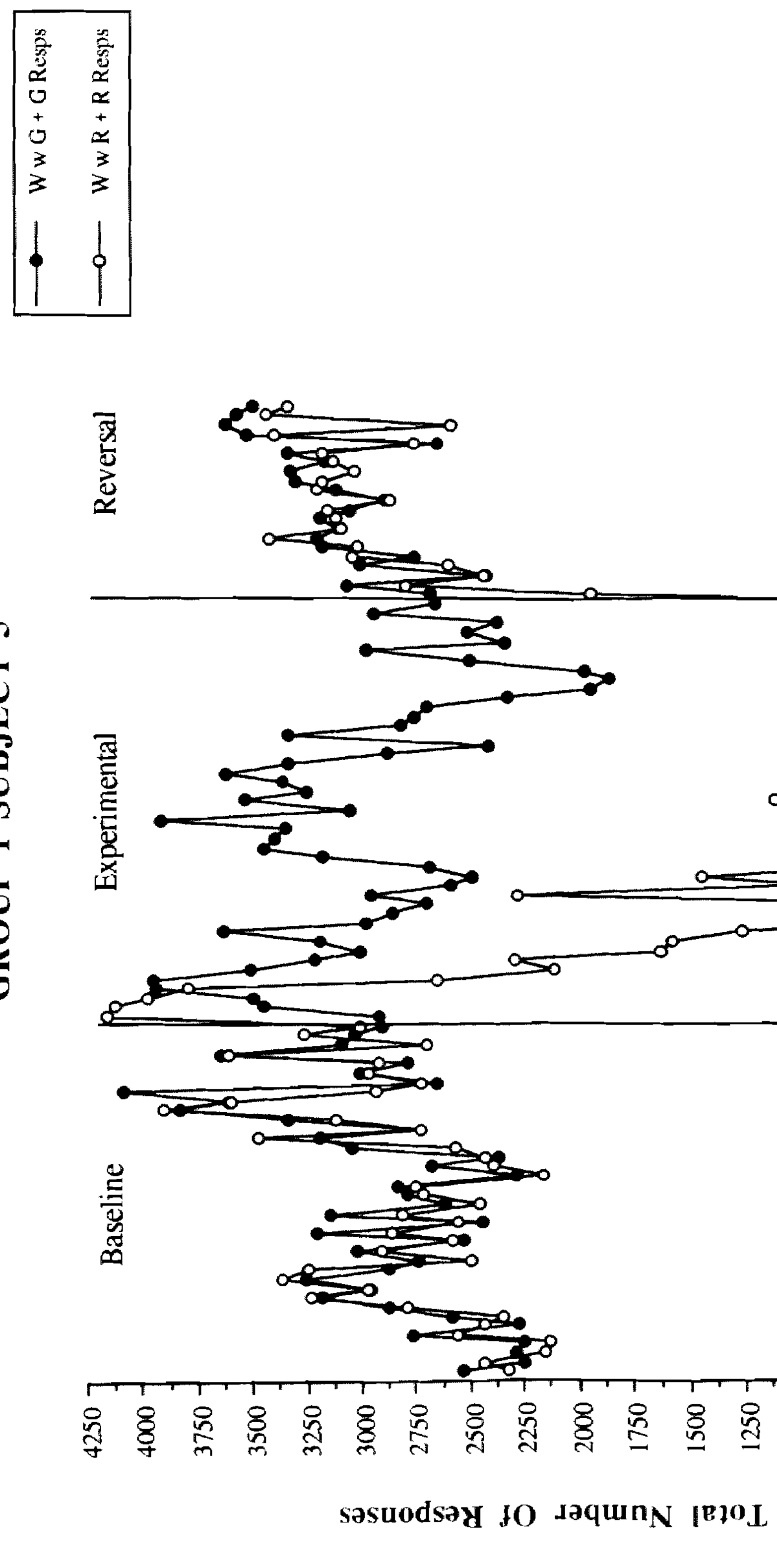



GROUP 1 SUBJECT 2
W w G + G Resps
W w R + R Resps
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105

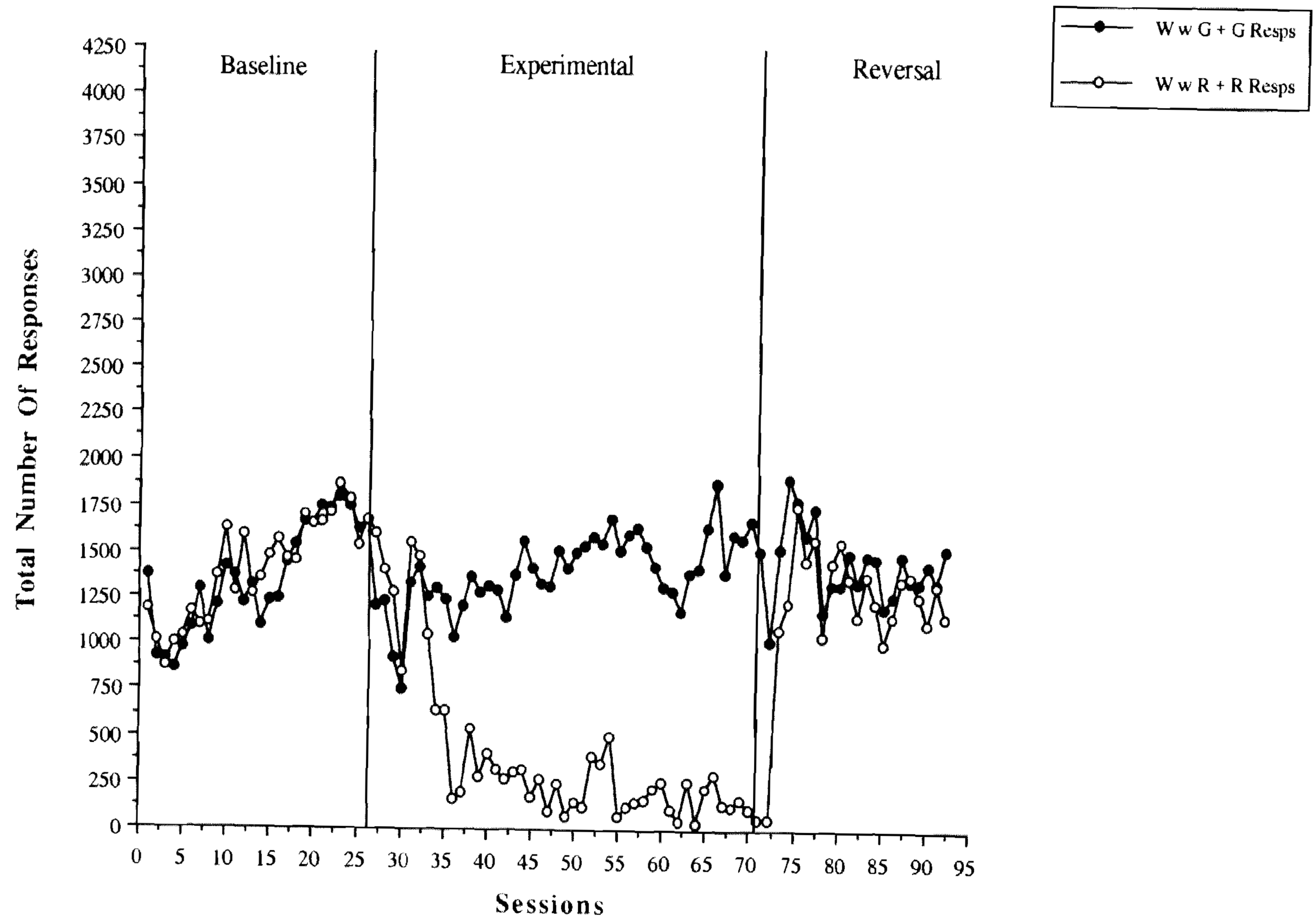

GROUP 1 SUBJECT 3
W w G + G Resps
W w R + R Resps
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105

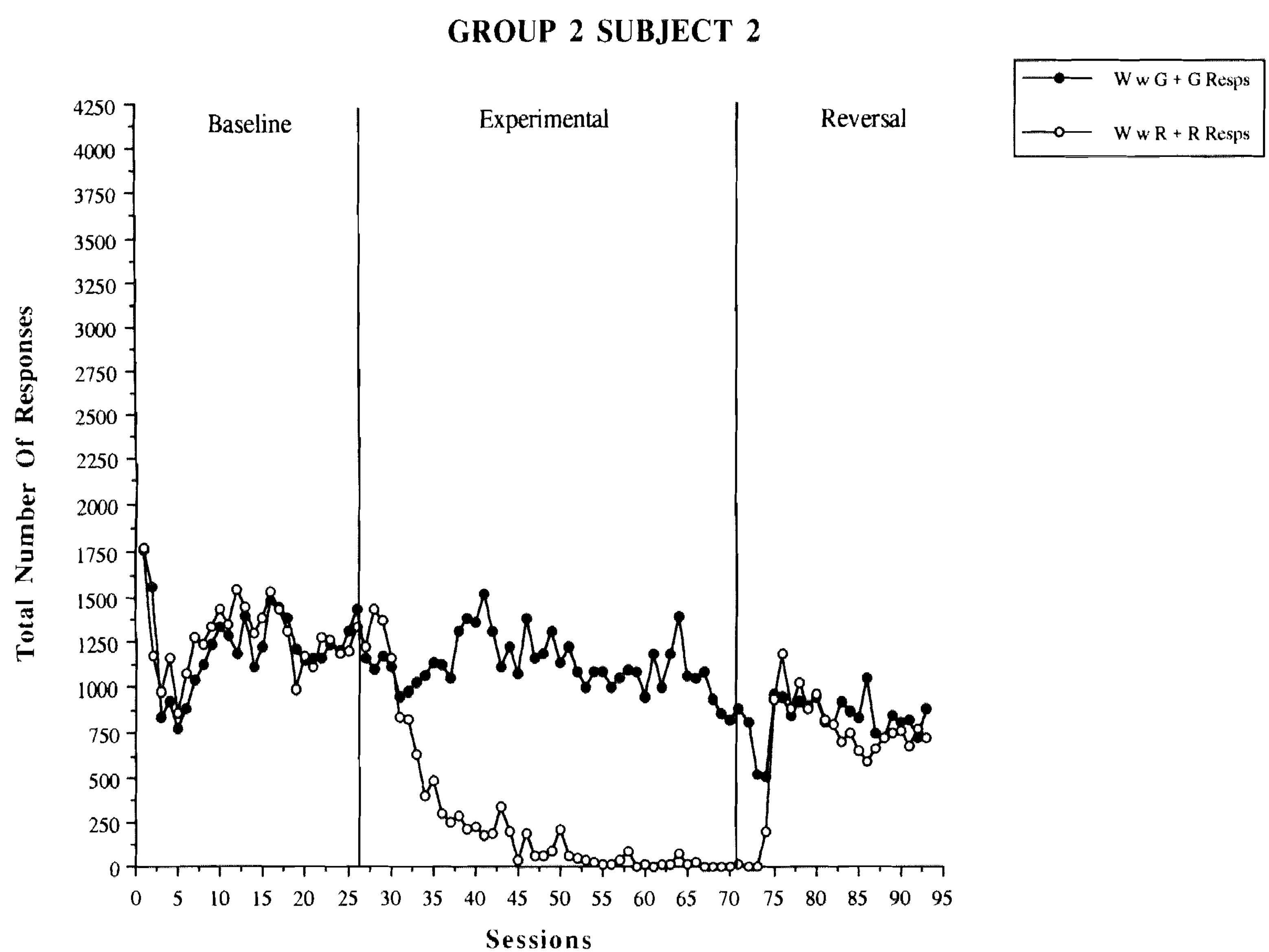

GROUP 1 SUBJECT 4
Baseline
Experimental
Reversal
W w G + G Resps
W w R + R Resps
Total Number Of Responses
Sessions
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105

GROUP 1 SUBJECT 5

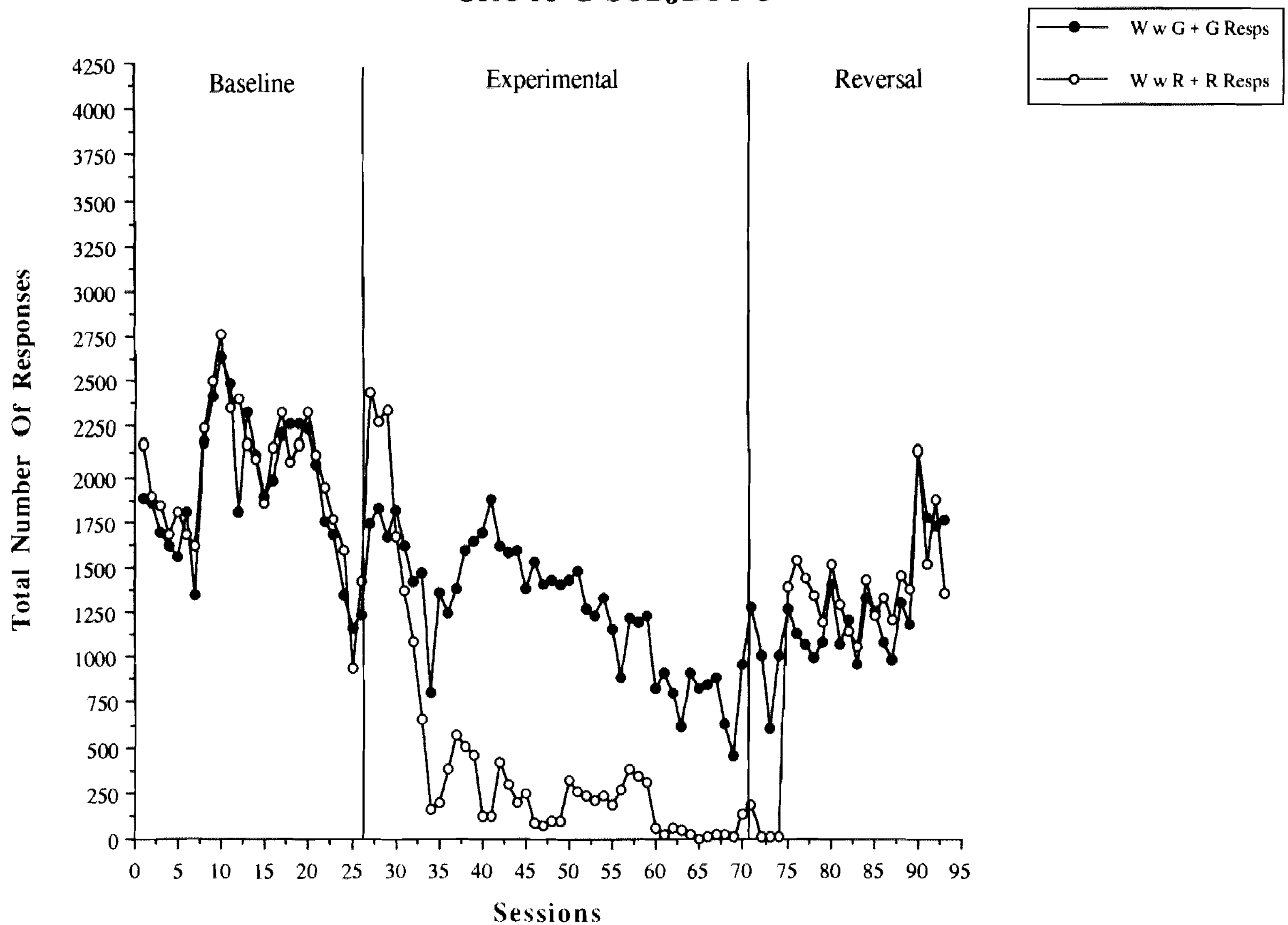


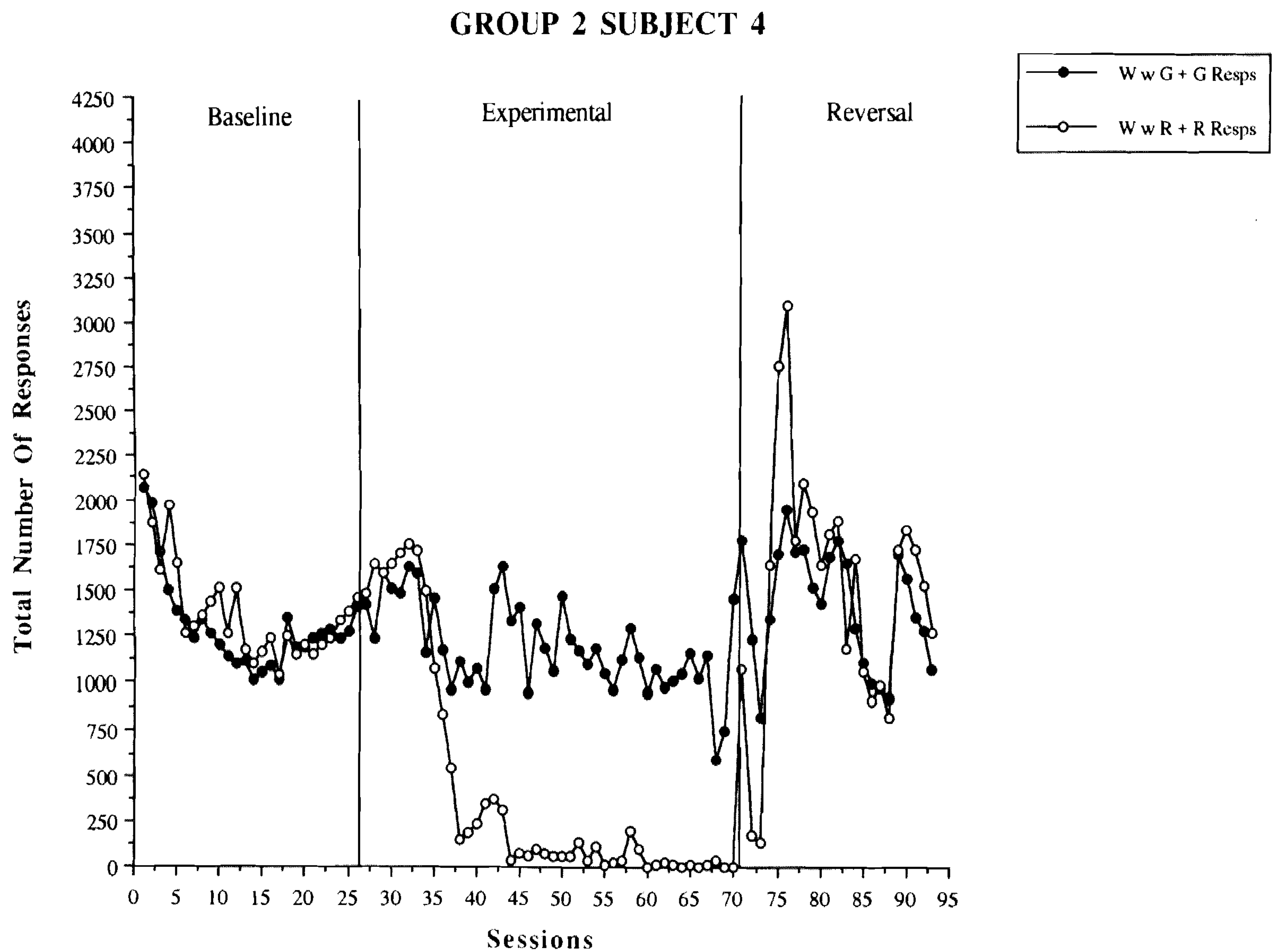
GROUP 2 SUBJECT 1

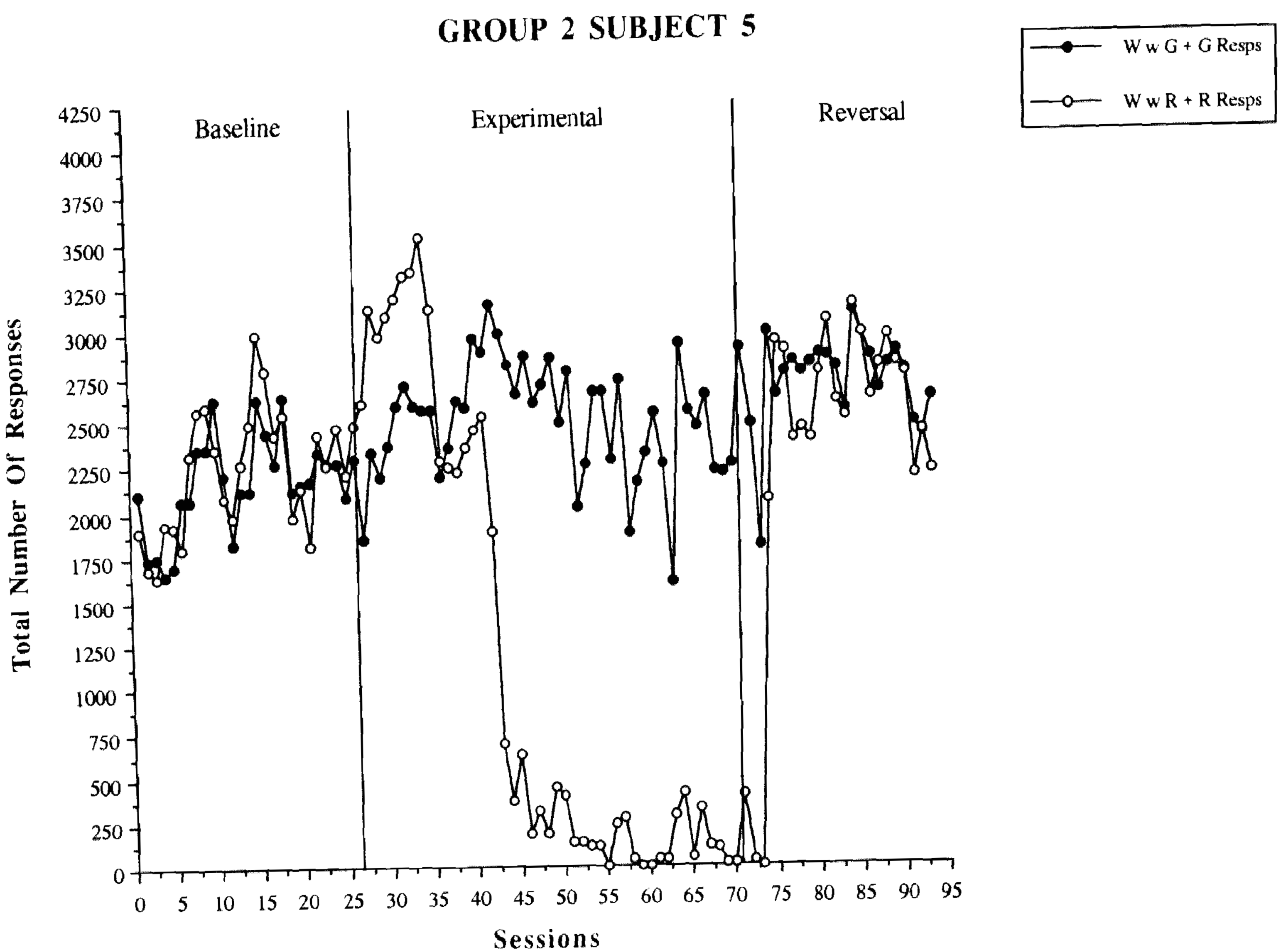



GROUP 2 SUBJECT 2
Baseline
Experimental
Reversal
W w G + G Resps
W w R + R Resps
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
Sessions

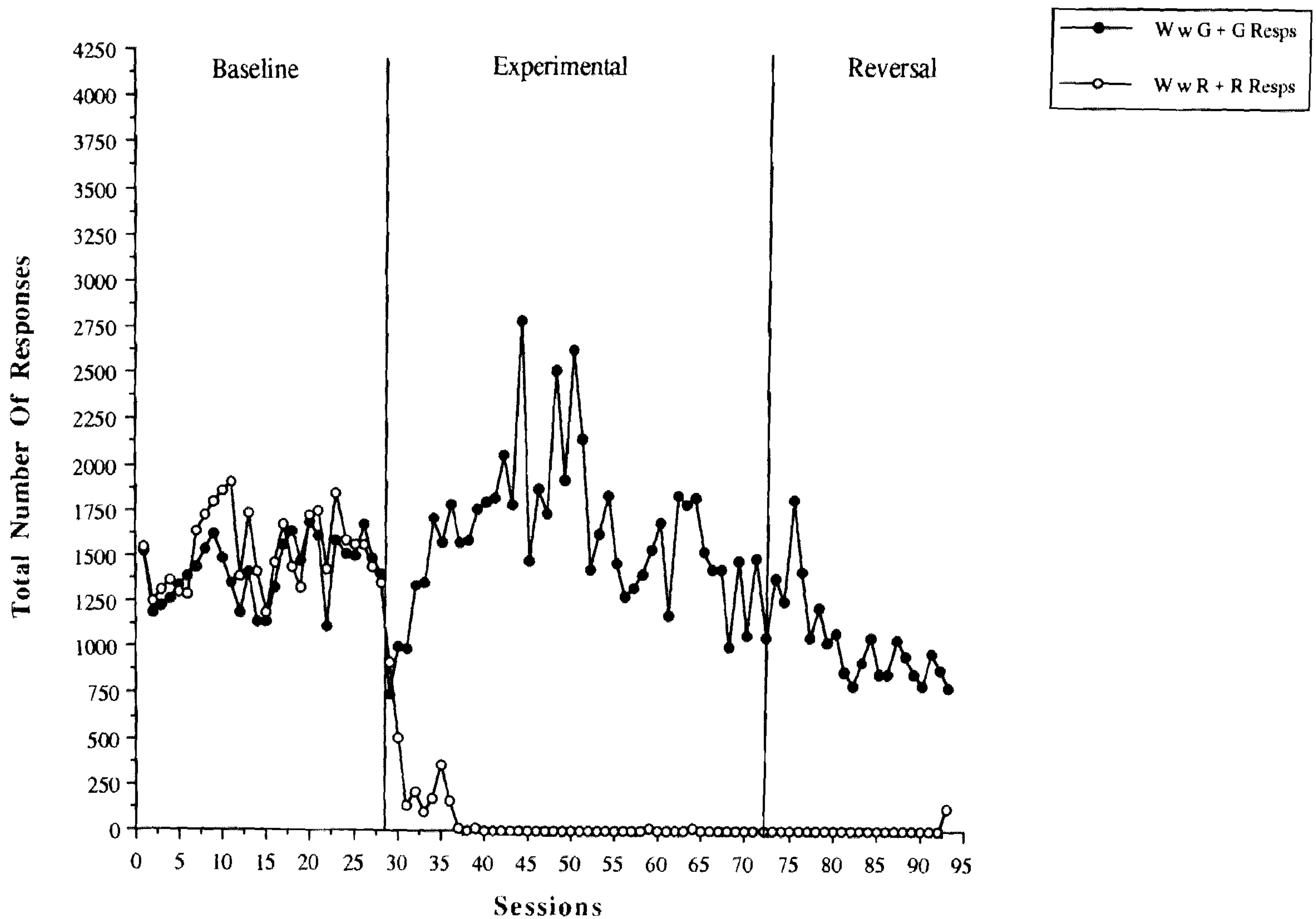
GROUP 2 SUBJECT 3

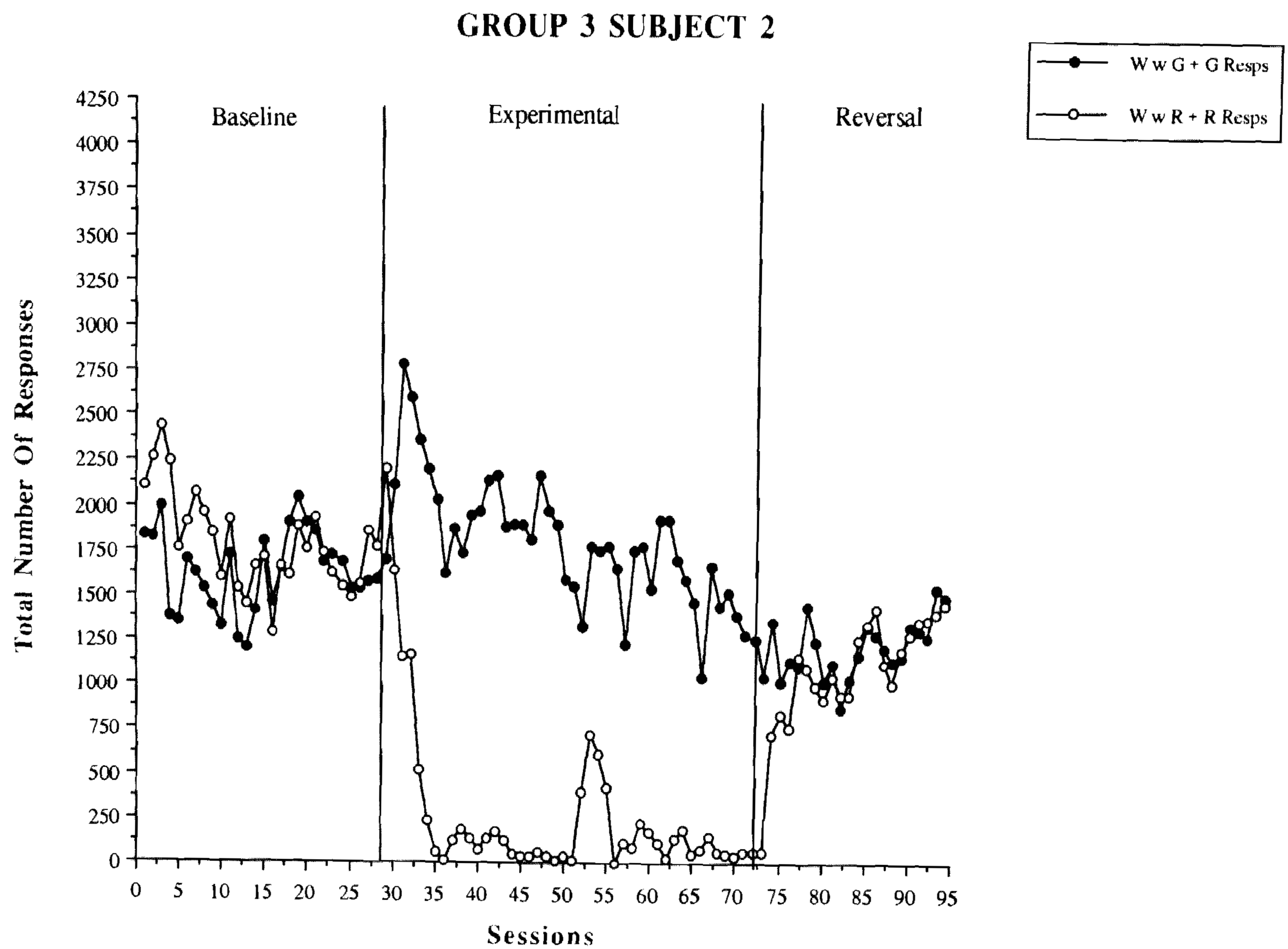



GROUP 2 SUBJECT 4
W w G + G Resps
W w R + R Resps
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95


GROUP 2 SUBJECT 5
W w G + G Resps
W w R + R Resps
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95

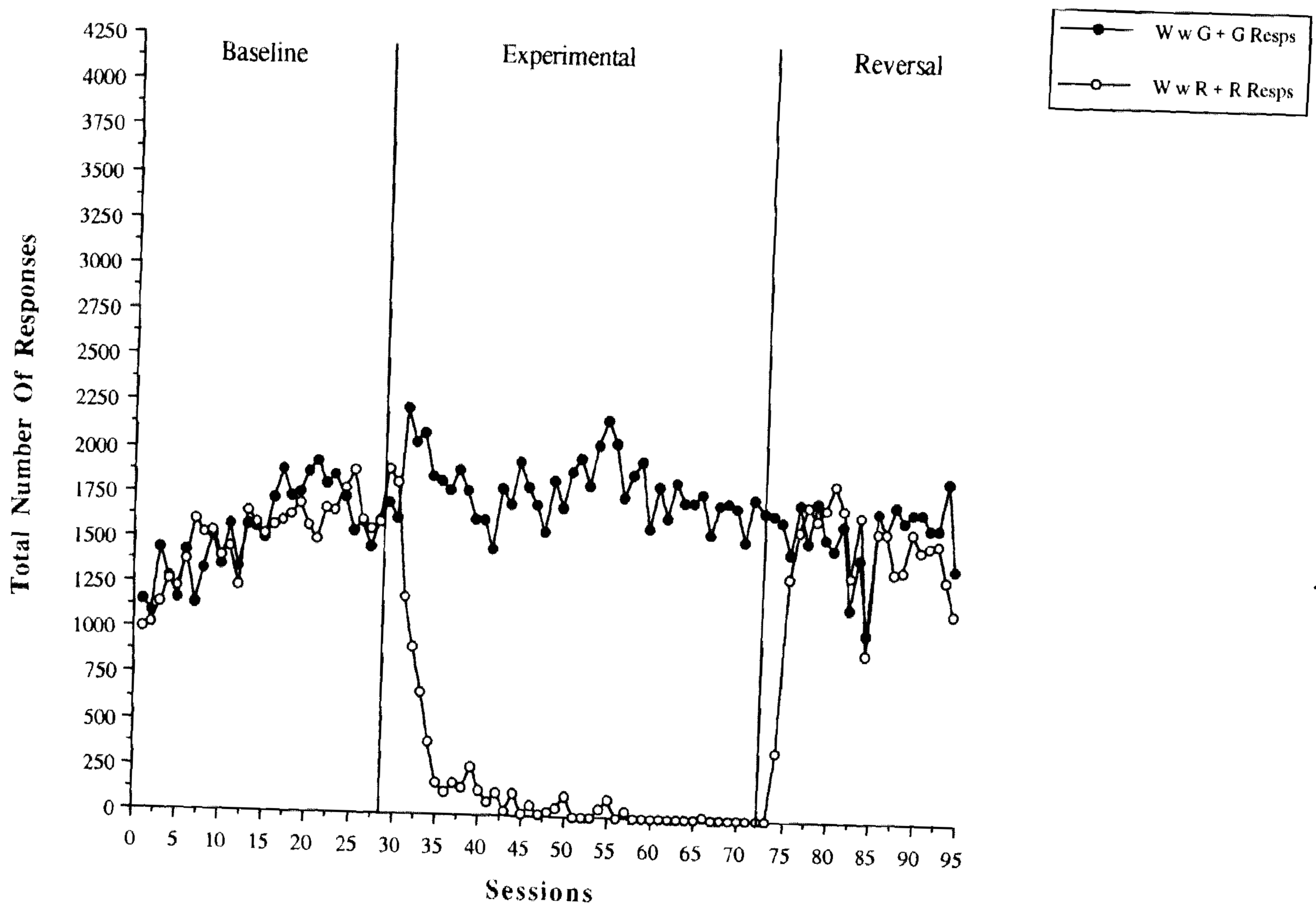
GROUP 3 SUBJECT 1

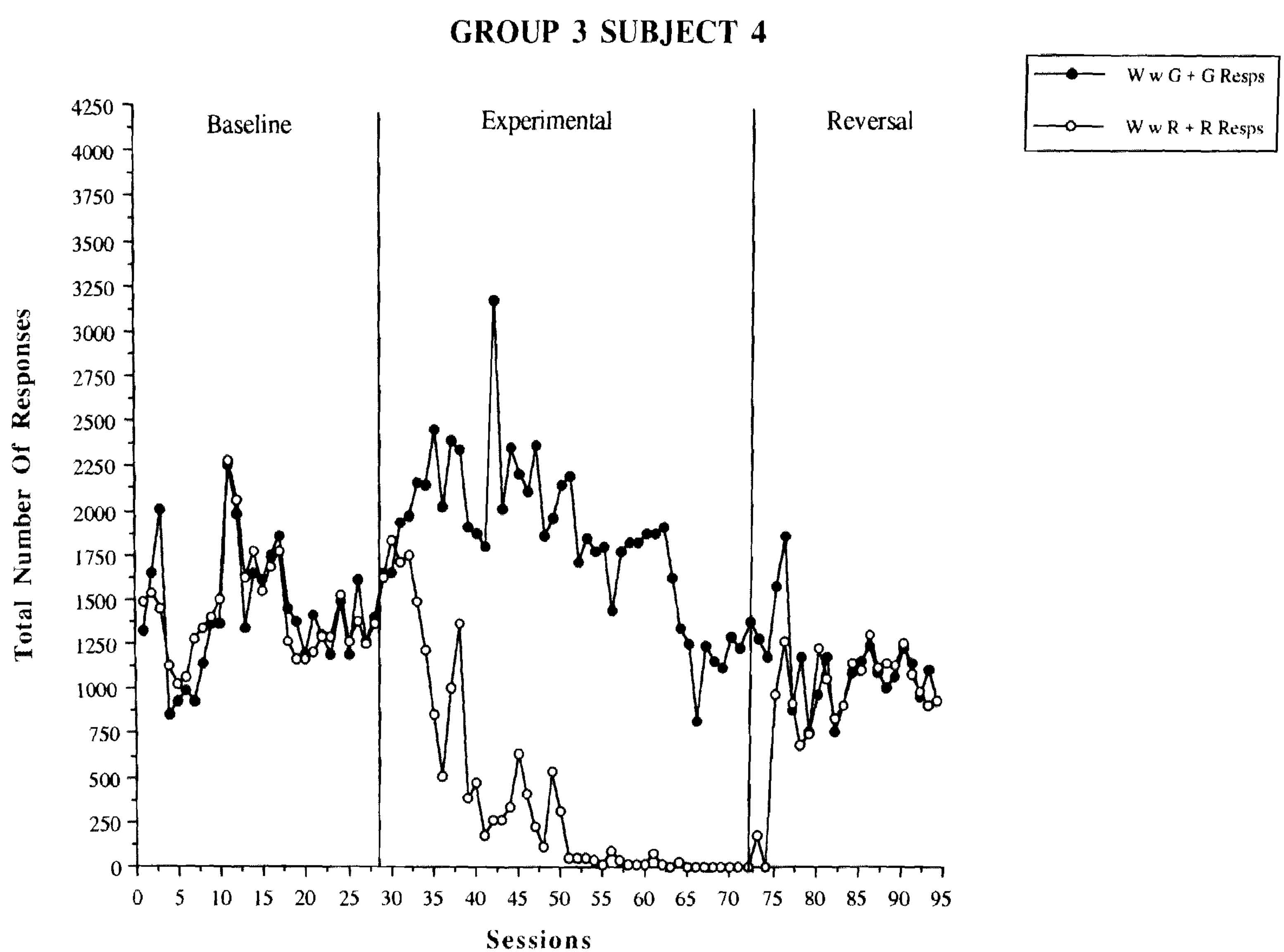




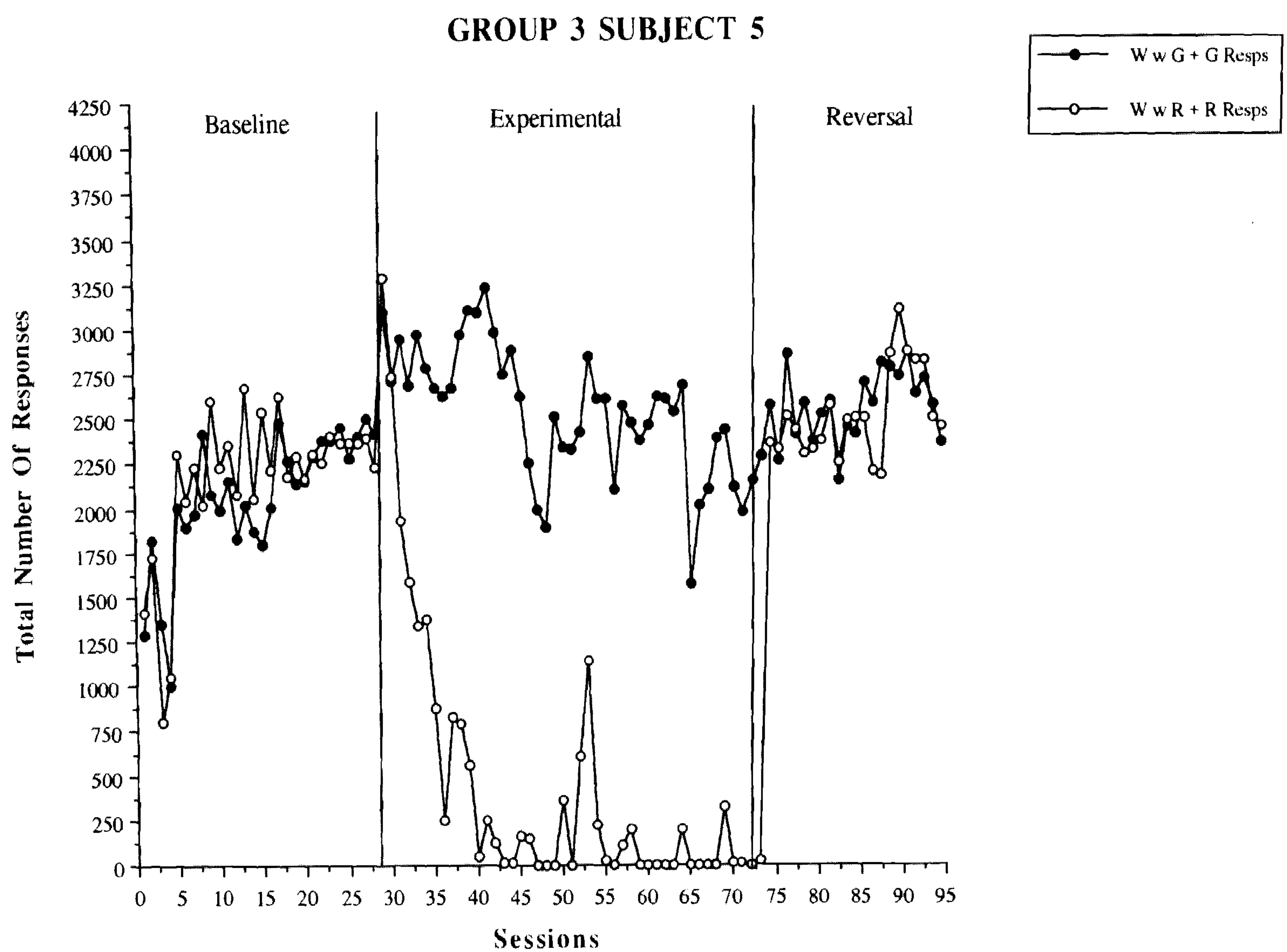
GROUP 3 SUBJECT 2
W w G + G Resps
W w R + R Resps
Baseline
Experimental
Reversal
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
Sessions

GROUP 3 SUBJECT 3





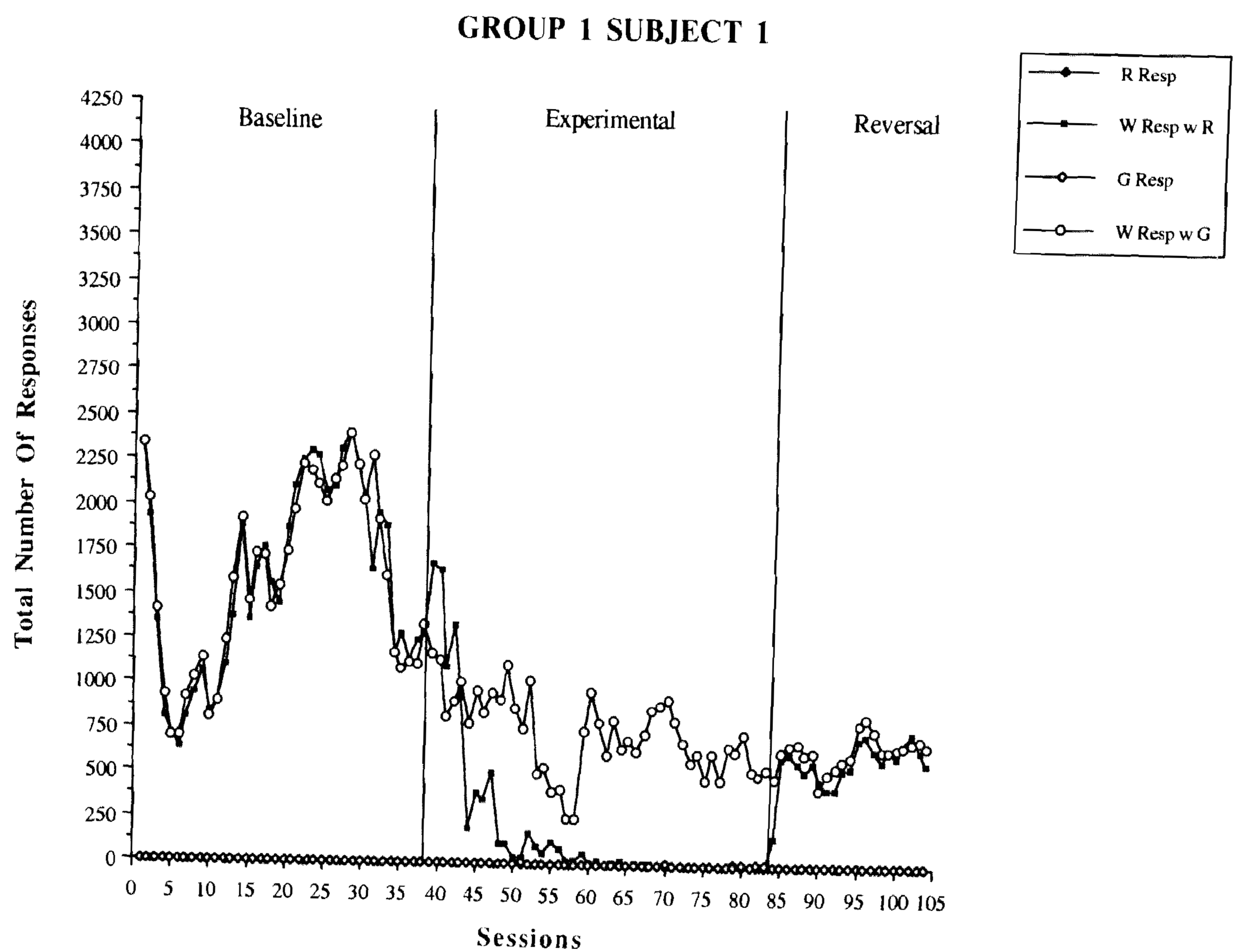
GROUP 3 SUBJECT 4
Total Number Of Responses
Sessions
Baseline
Experimental
Reversal
W w G + G Resps
W w R + R Resps
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95

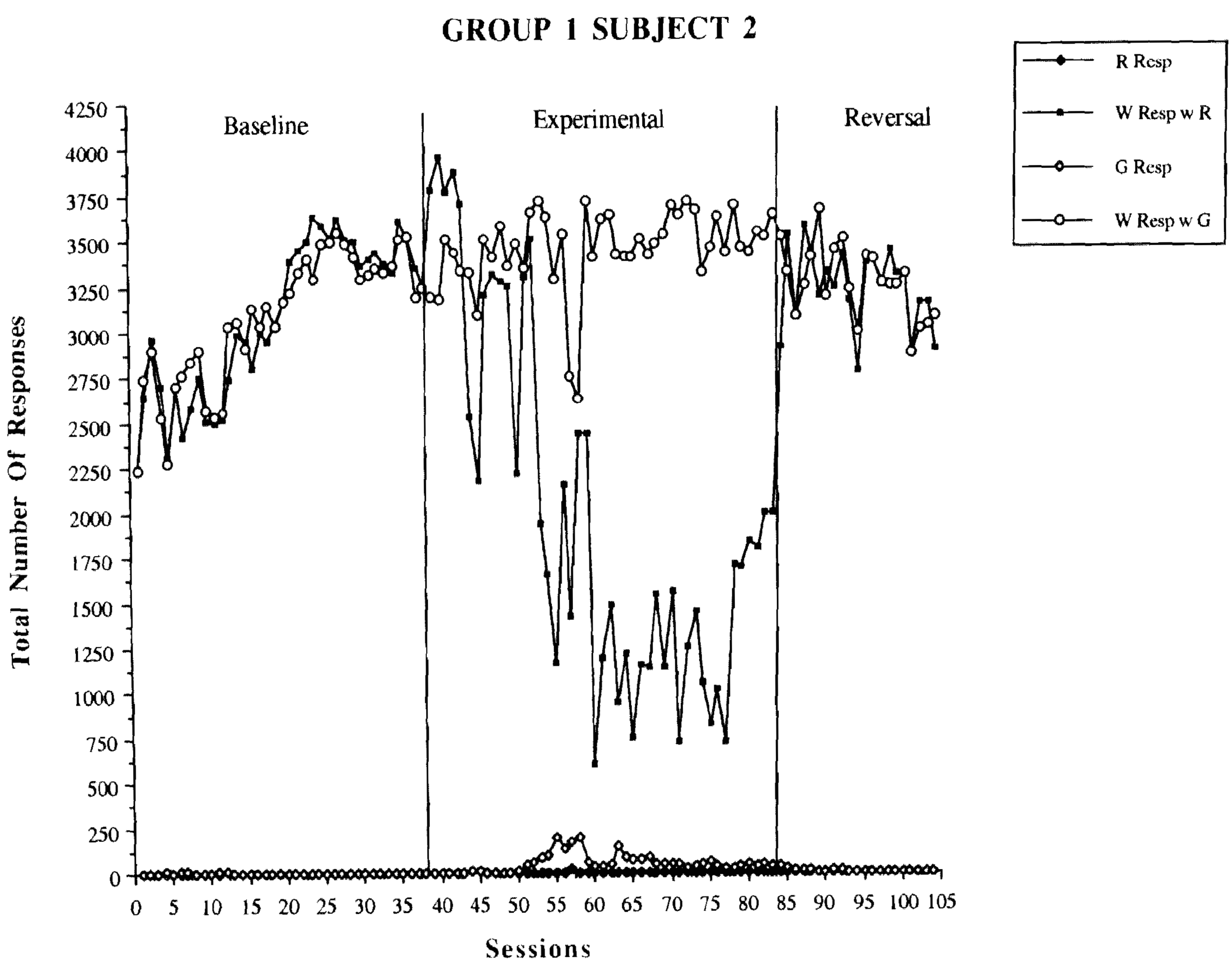


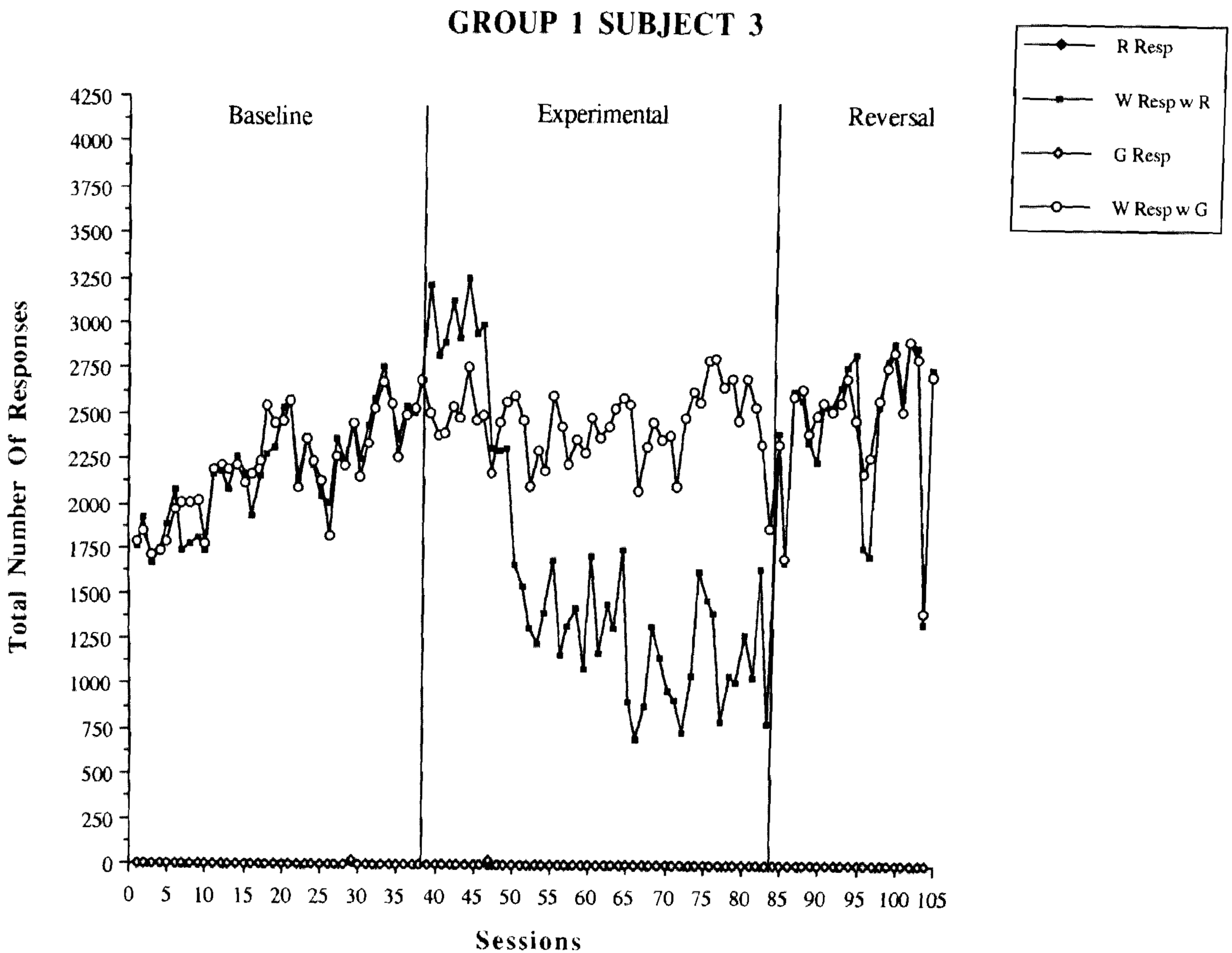
GROUP 3 SUBJECT 5
W w G + G Resps
W w R + R Resps
Baseline
Experimental
Reversal
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
Sessions

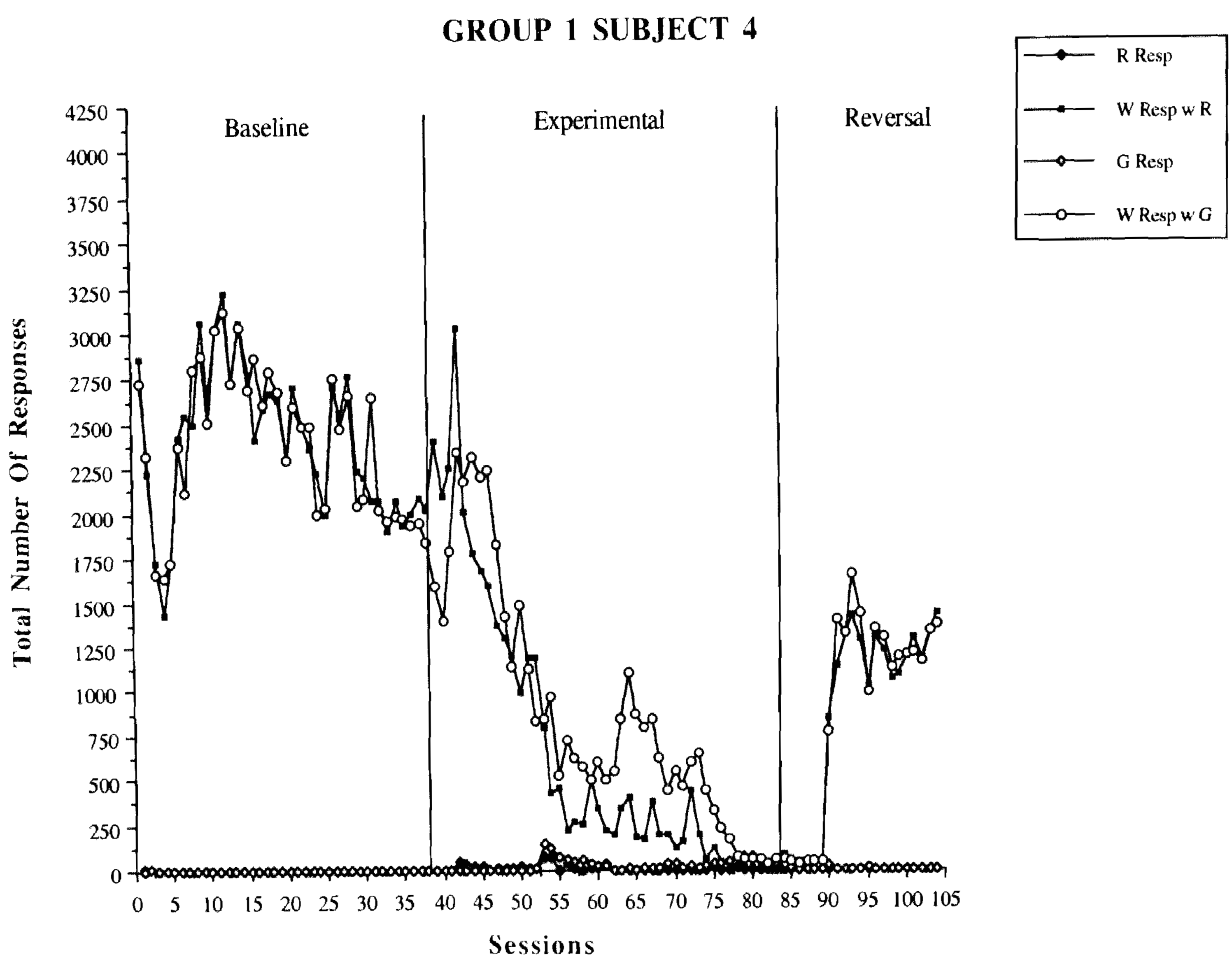
Appendix C

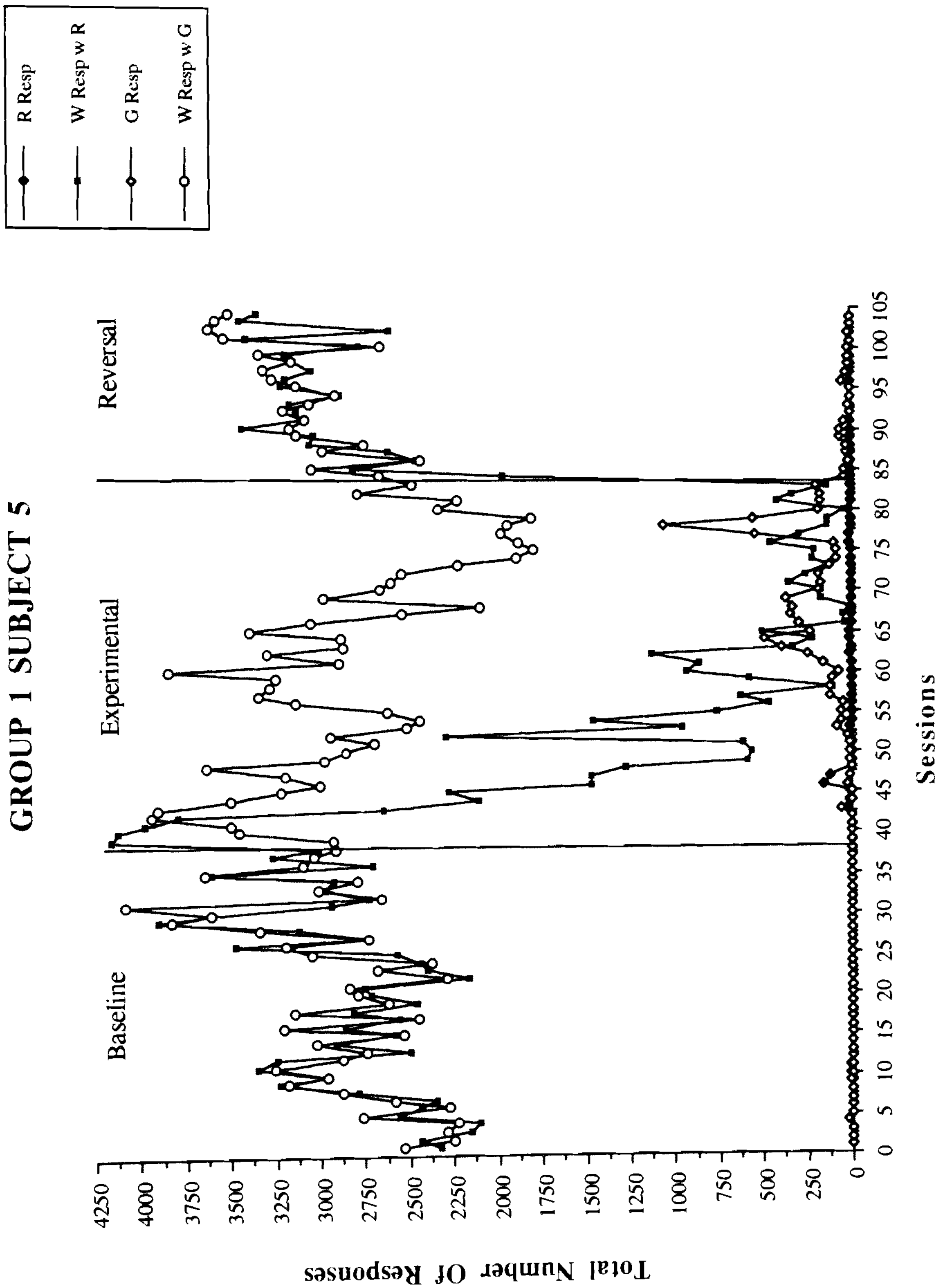
Figures Depicting the Performance of Each Subject with Responses to Each Key Light

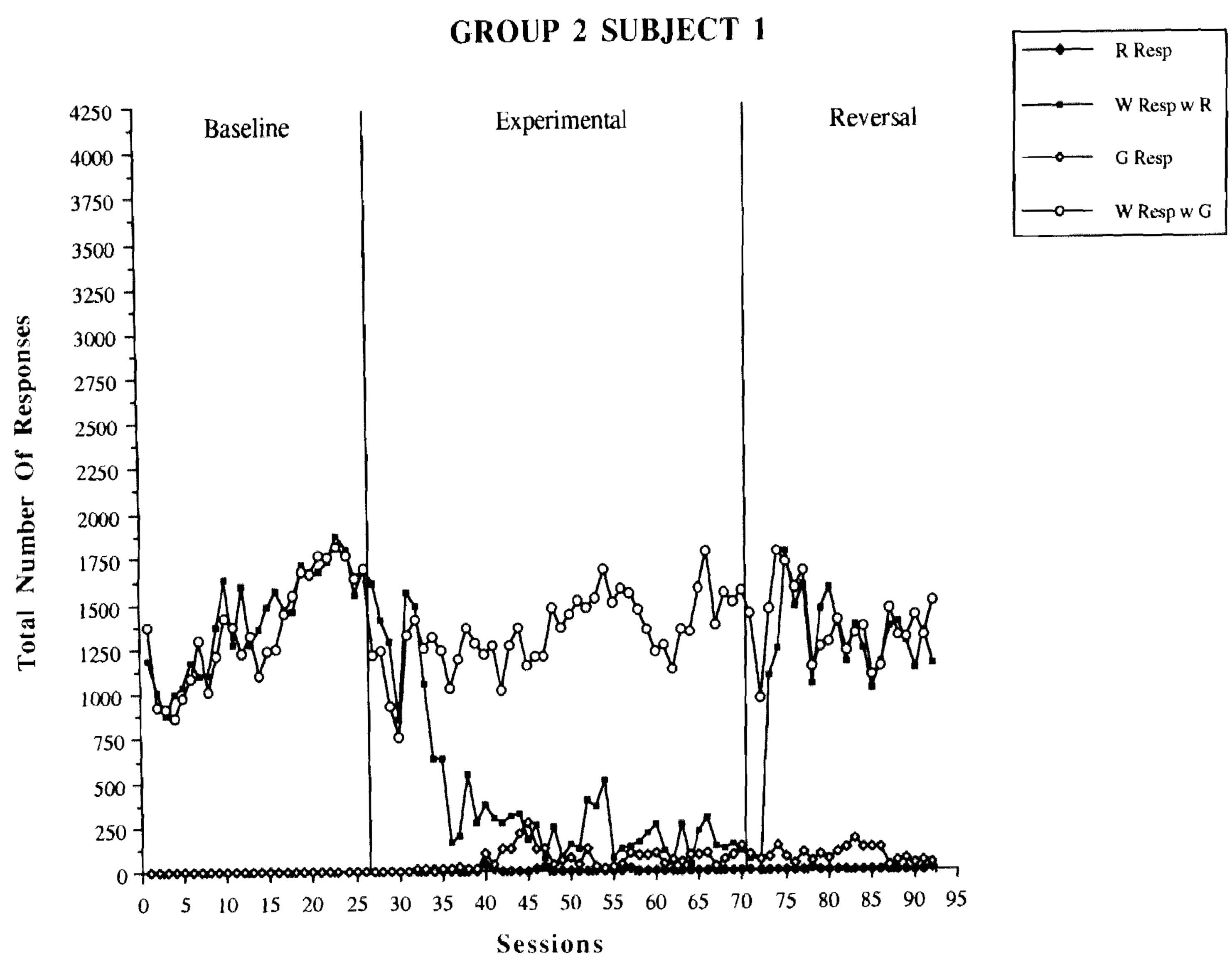

GROUP 1 SUBJECT 1
Baseline
Experimental
Reversal
R Resp
W Resp w R
G Resp
W Resp w G
Total Number Of Responses
Sessions
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105

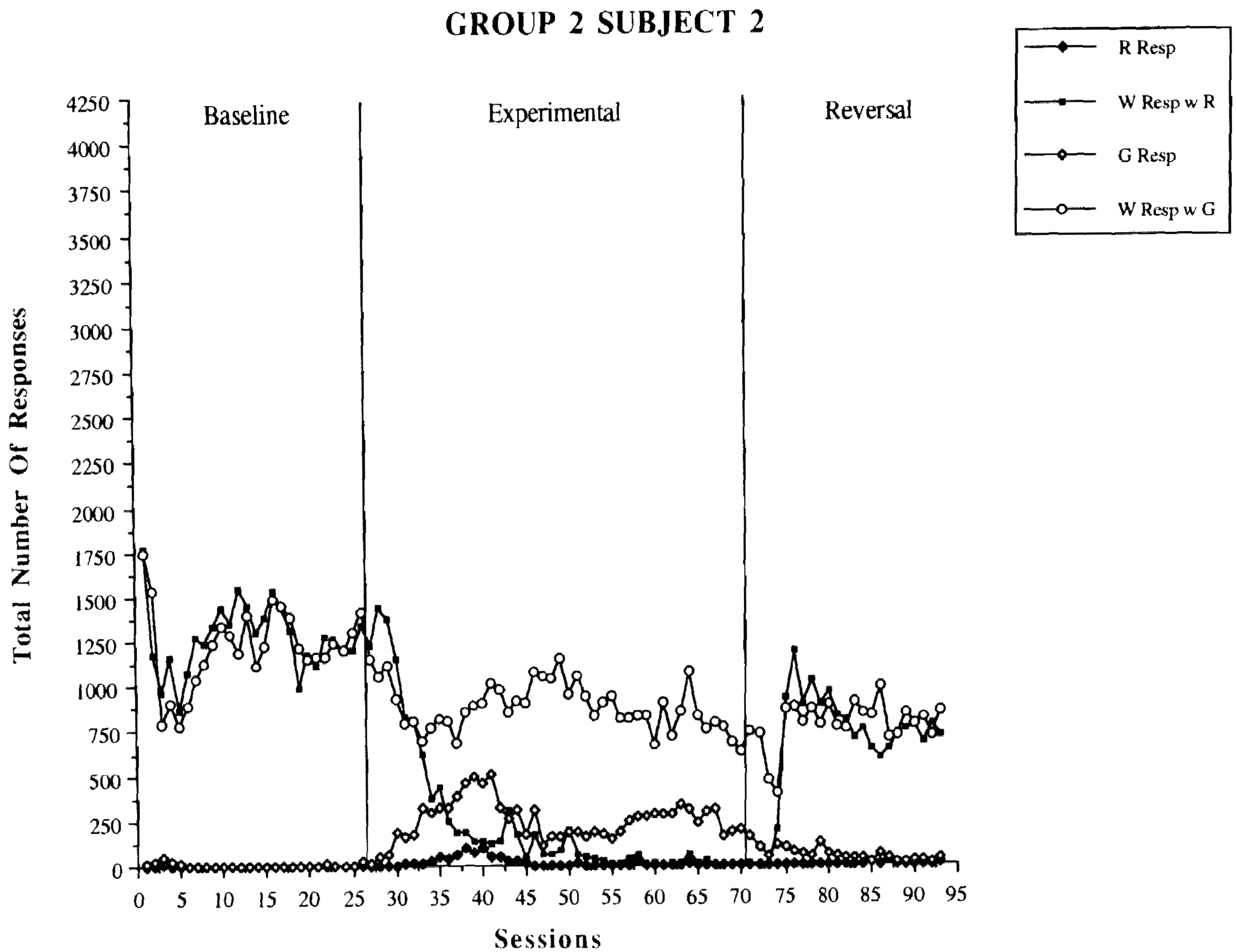

GROUP 1 SUBJECT 2
Baseline
Experimental
Reversal
R Resp
W Resp w R
G Resp
W Resp w G
Total Number Of Responses
Sessions
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105


GROUP 1 SUBJECT 3
R Resp
W Resp w R
G Resp
W Resp w G
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105

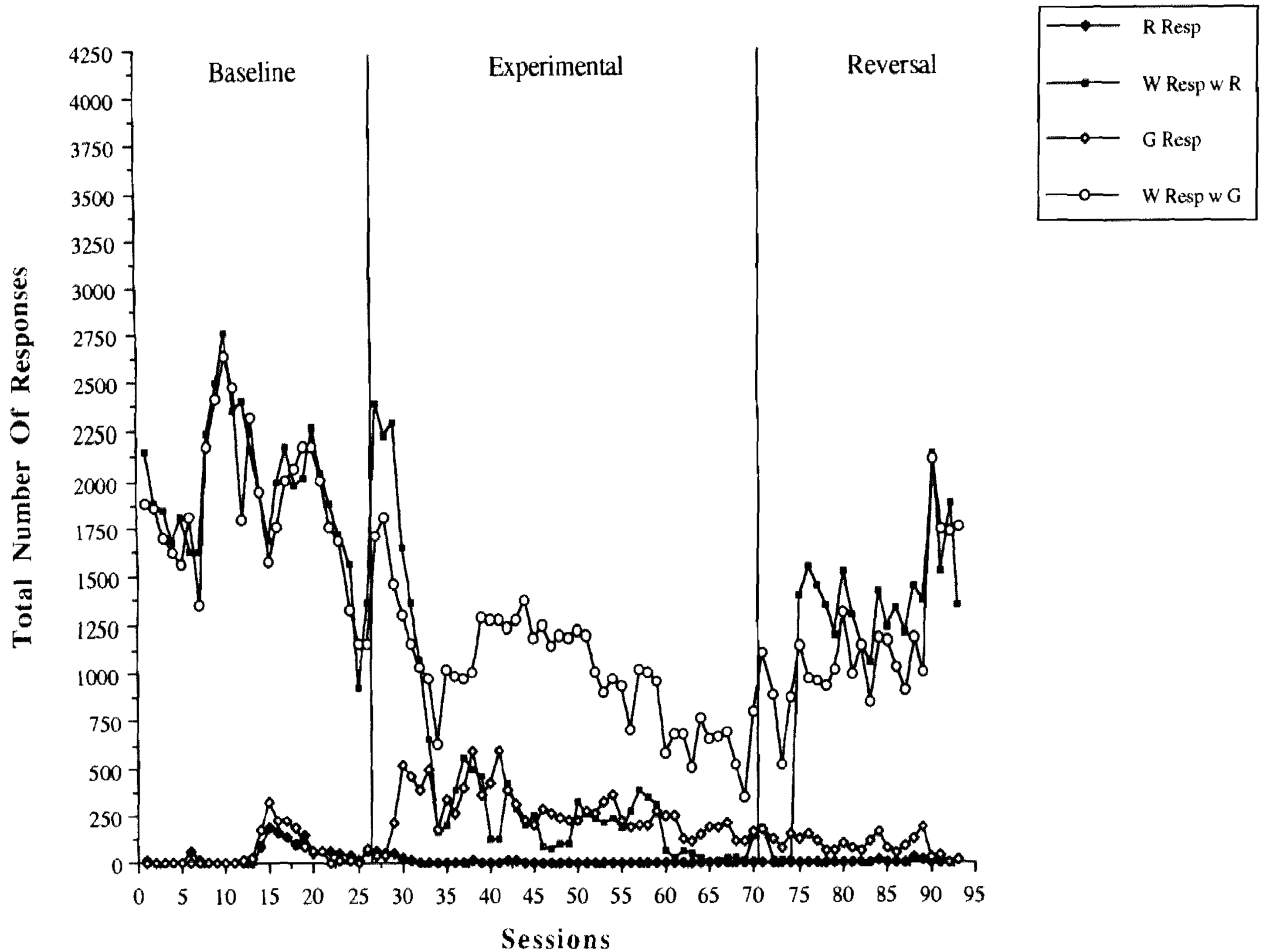

GROUP 1 SUBJECT 4
Baseline
Experimental
Reversal
R Resp
W Resp w R
G Resp
W Resp w G
Total Number Of Responses
Sessions
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105

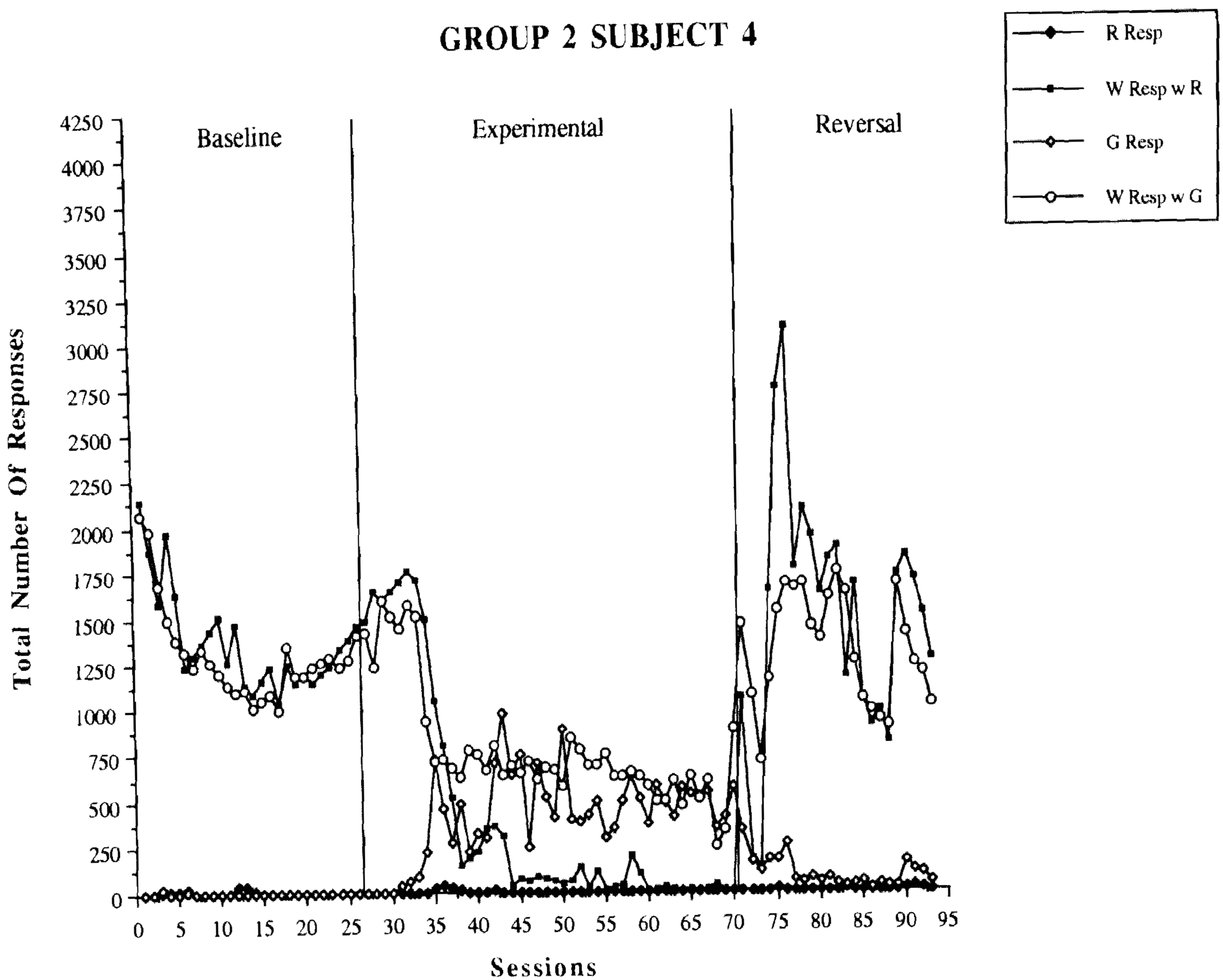

GROUP 1 SUBJECT 5
R Resp
W Resp w R
G Resp
W Resp w G
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250

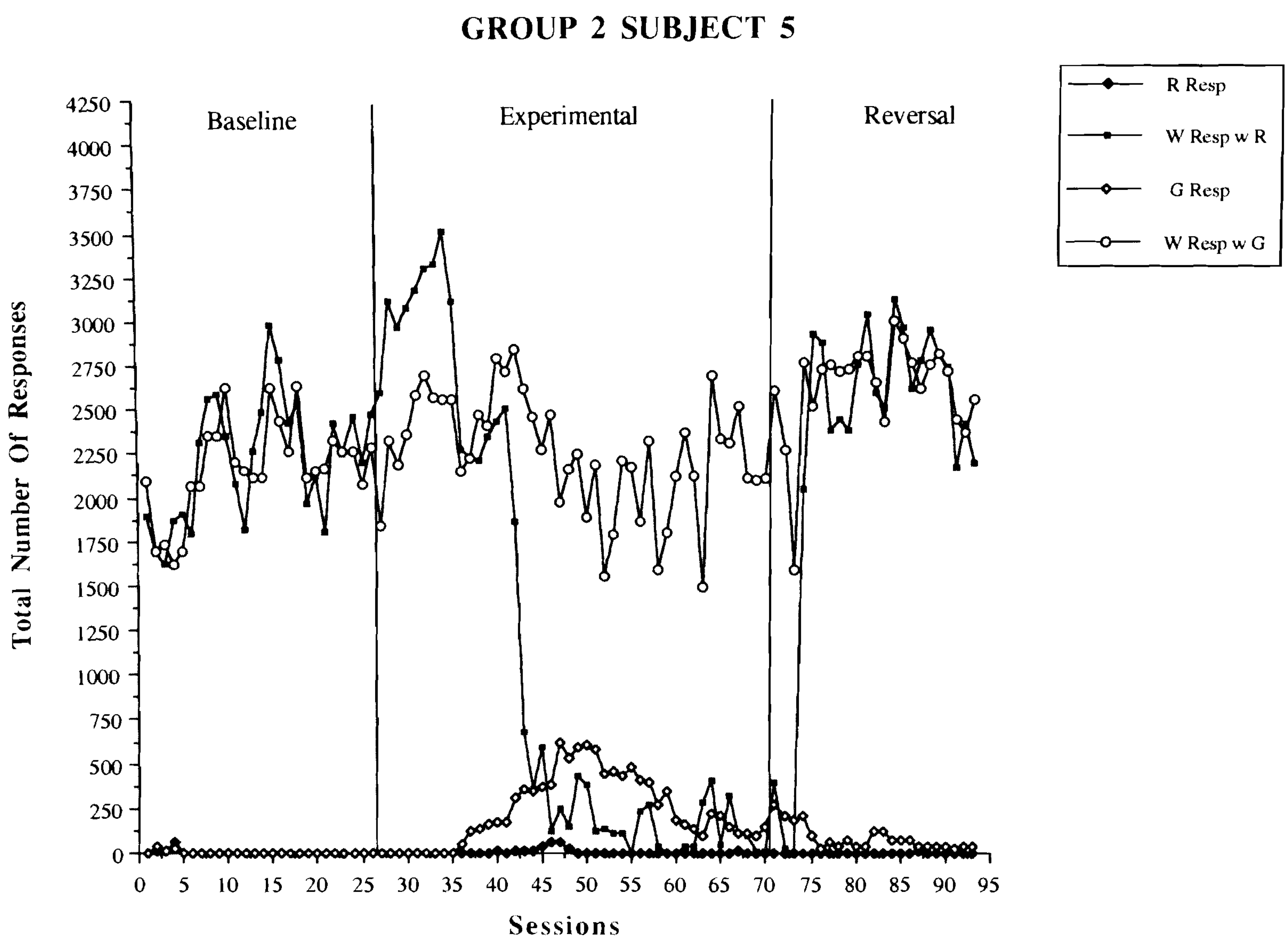

GROUP 2 SUBJECT 1
Baseline
Experimental
Reversal
R Resp
W Resp w R
G Resp
W Resp w G
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
Sessions

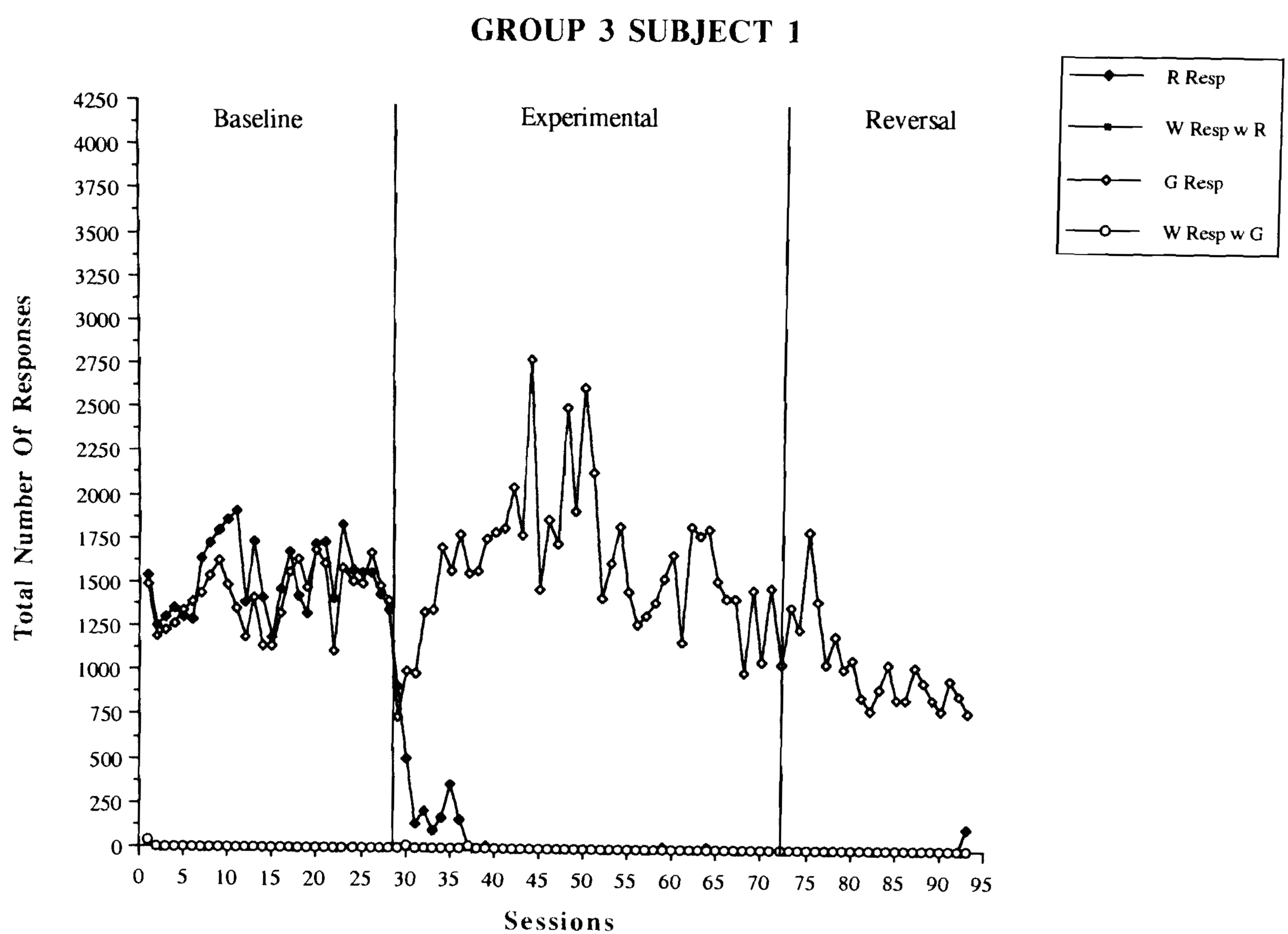

GROUP 2 SUBJECT 2
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
R Resp
W Resp w R
G Resp
W Resp w G

GROUP 2 SUBJECT 3

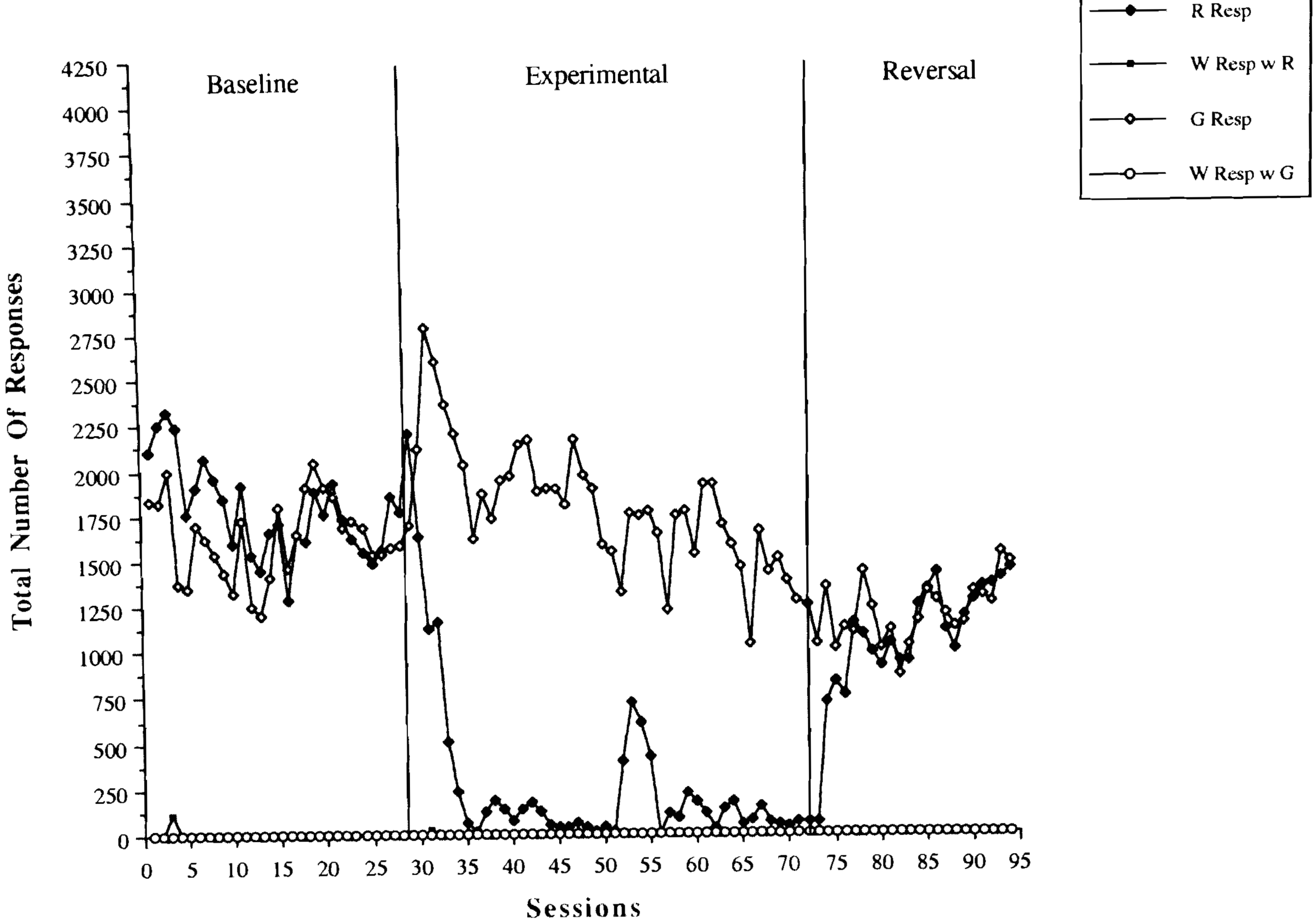


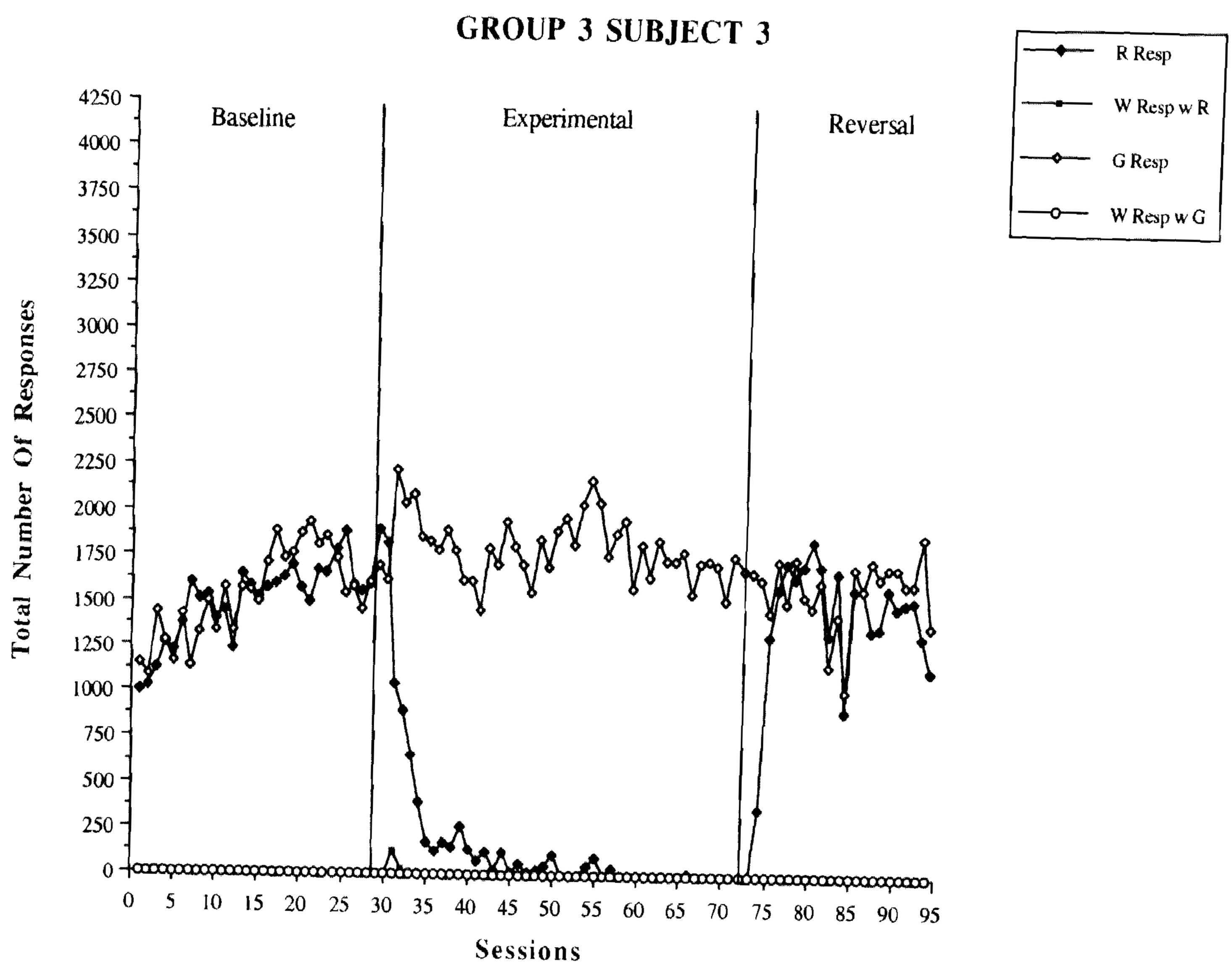

GROUP 2 SUBJECT 4
Baseline
Experimental
Reversal
R Resp
W Resp w R
G Resp
W Resp w G
Total Number Of Responses
Sessions
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95

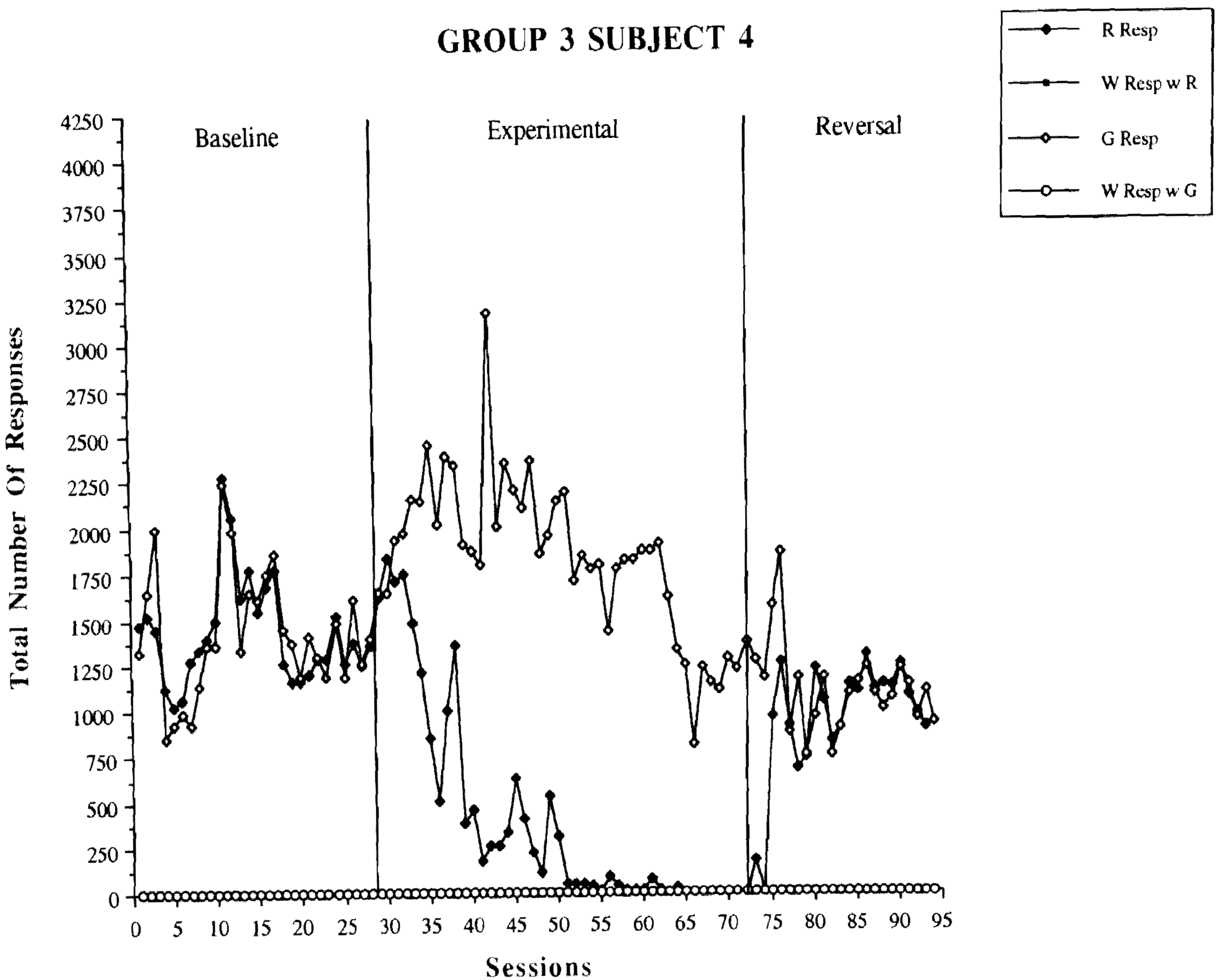

GROUP 2 SUBJECT 5
Baseline
Experimental
Reversal
R Resp
W Resp w R
G Resp
W Resp w G
Total Number Of Responses
Sessions
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95


GROUP 3 SUBJECT 1
Baseline
Experimental
Reversal
R Resp
W Resp w R
G Resp
W Resp w G
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
Sessions

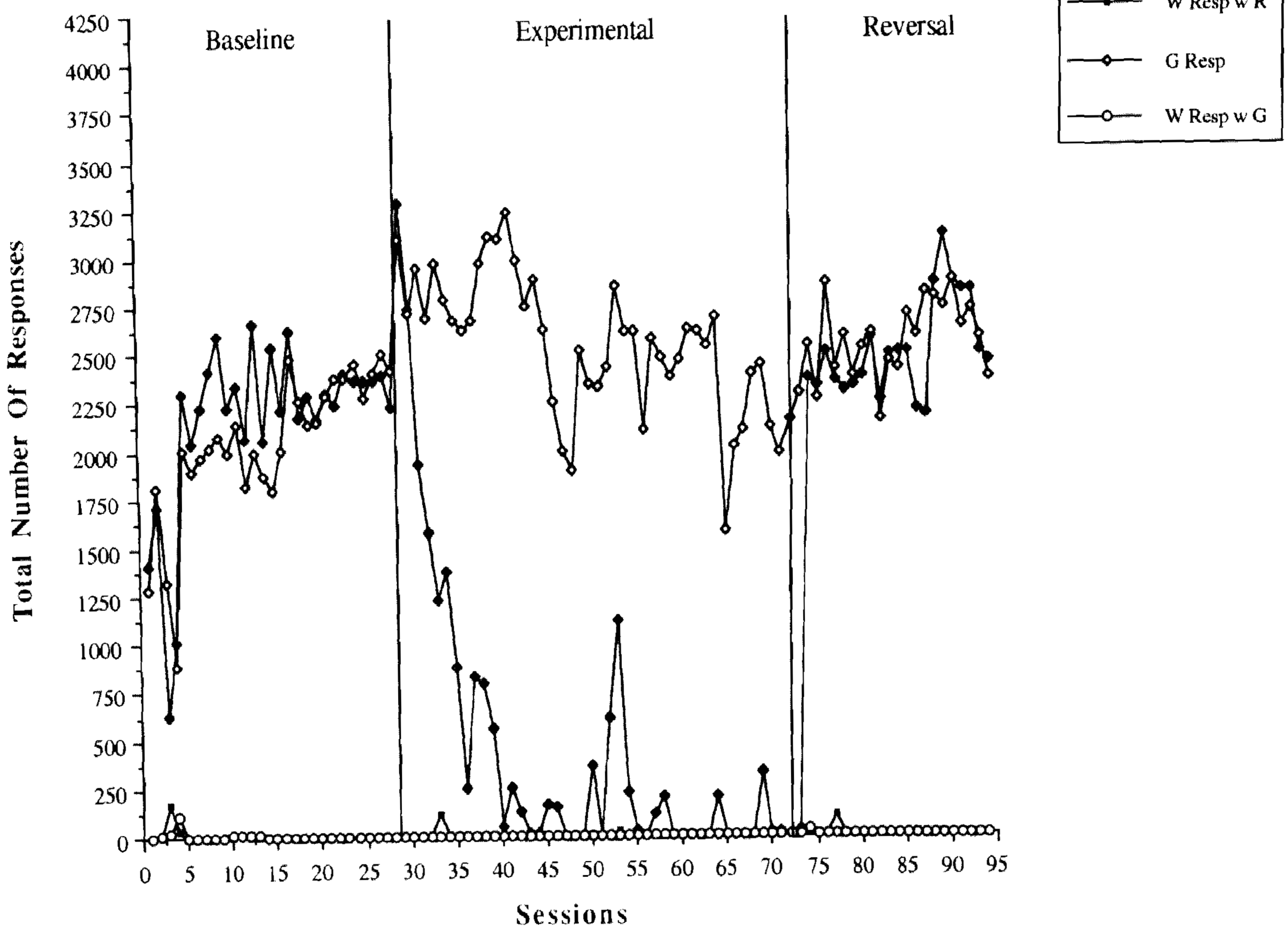
GROUP 3 SUBJECT 2




GROUP 3 SUBJECT 3
Baseline
Experimental
Reversal
R Resp
W Resp w R
G Resp
W Resp w G
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
Sessions


GROUP 3 SUBJECT 4
R Resp
W Resp w R
G Resp
W Resp w G
Baseline
Experimental
Reversal
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
Sessions

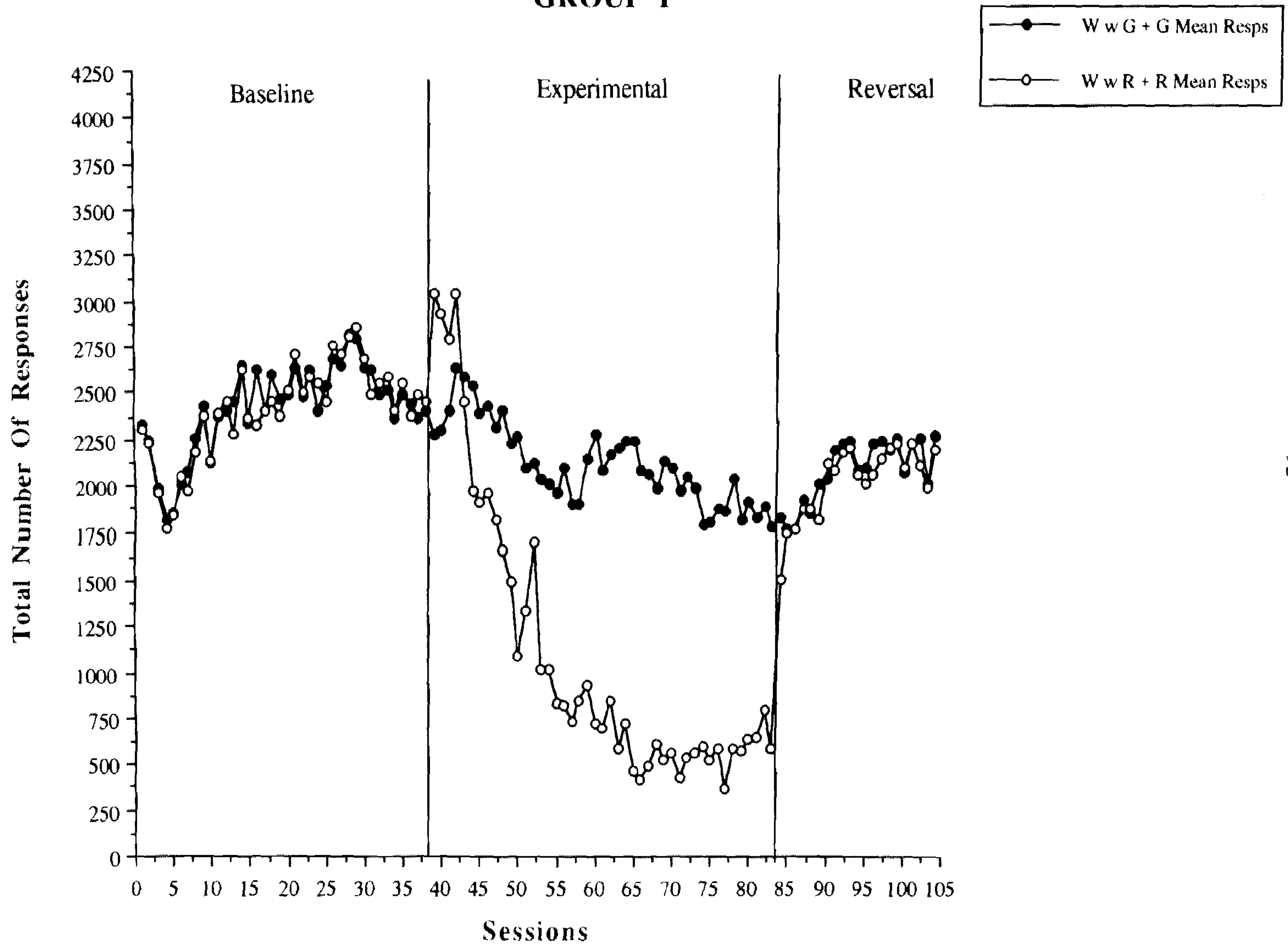
GROUP 3 SUBJECT 5



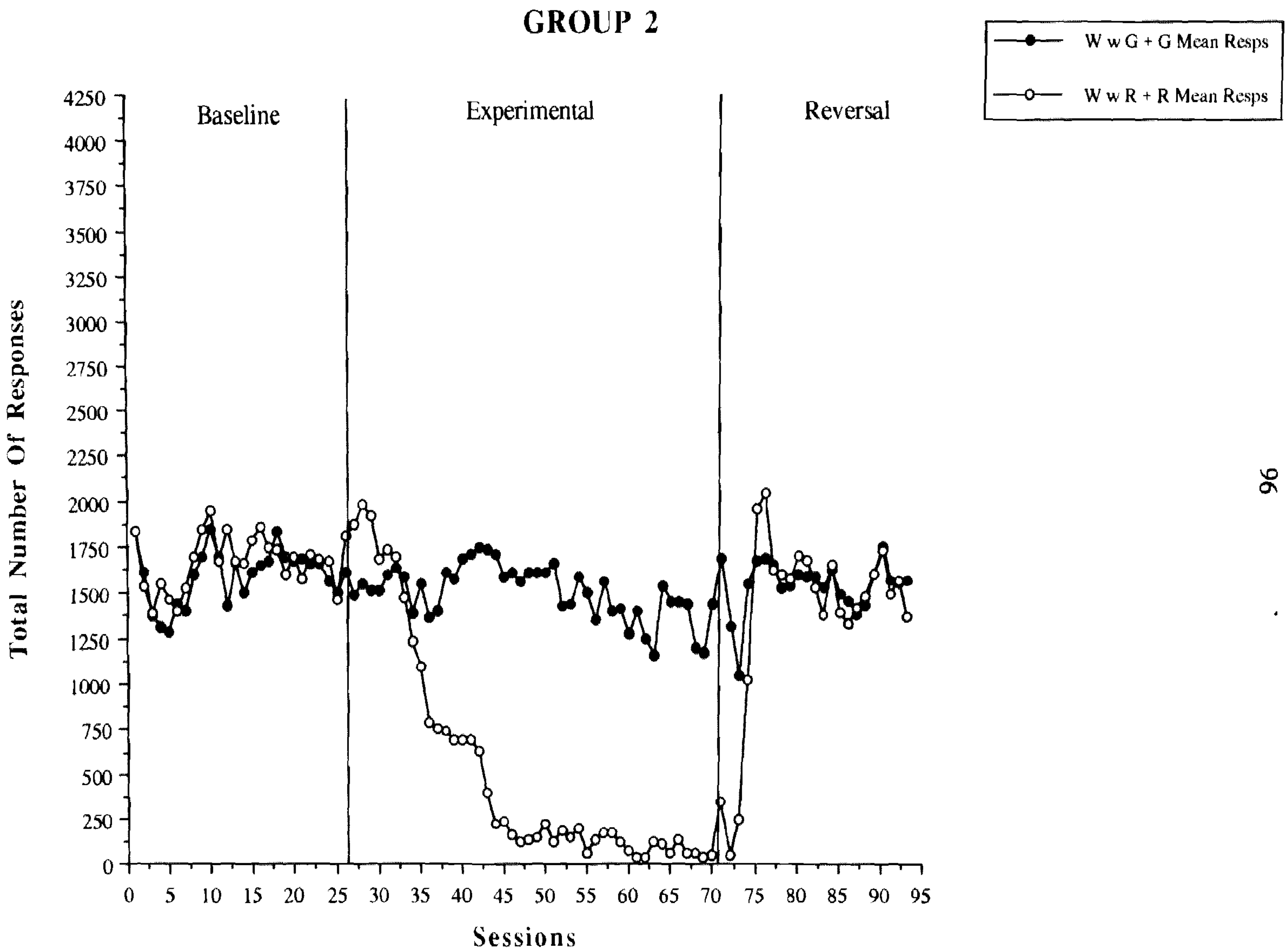
Appendix D

Figures Depicting Group Results with Mean Responses to Operant Key Summed with Mean Responses to Signal Key or Mean Responses to Alternative Key for Each Component Type

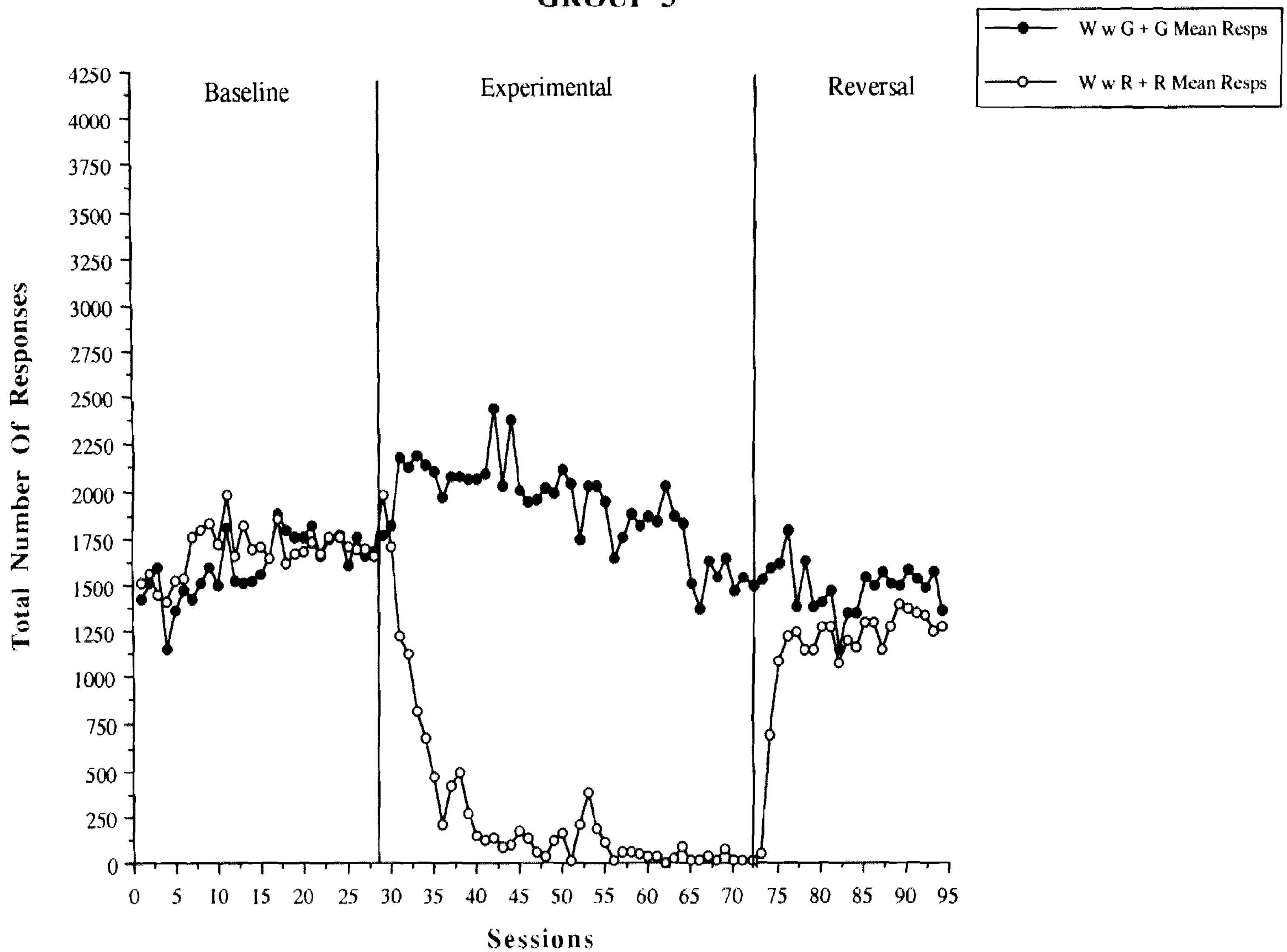
GROUP 1



Baseline
Experimental
Reversal
W w G + G Mean Resps
W w R + R Mean Resps
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105
Sessions

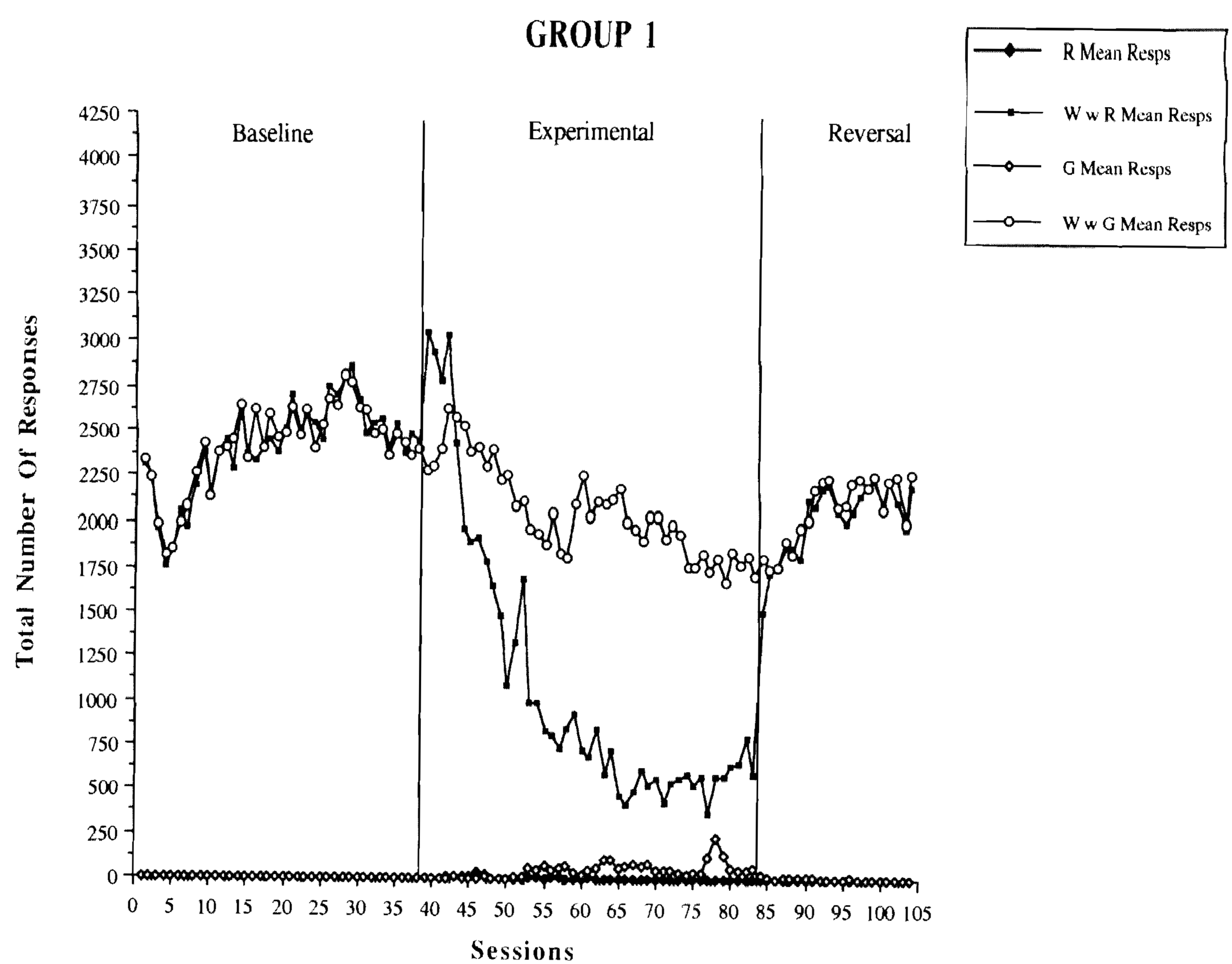

GROUP 2
W w G + G Mean Resps
W w R + R Mean Resps
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95

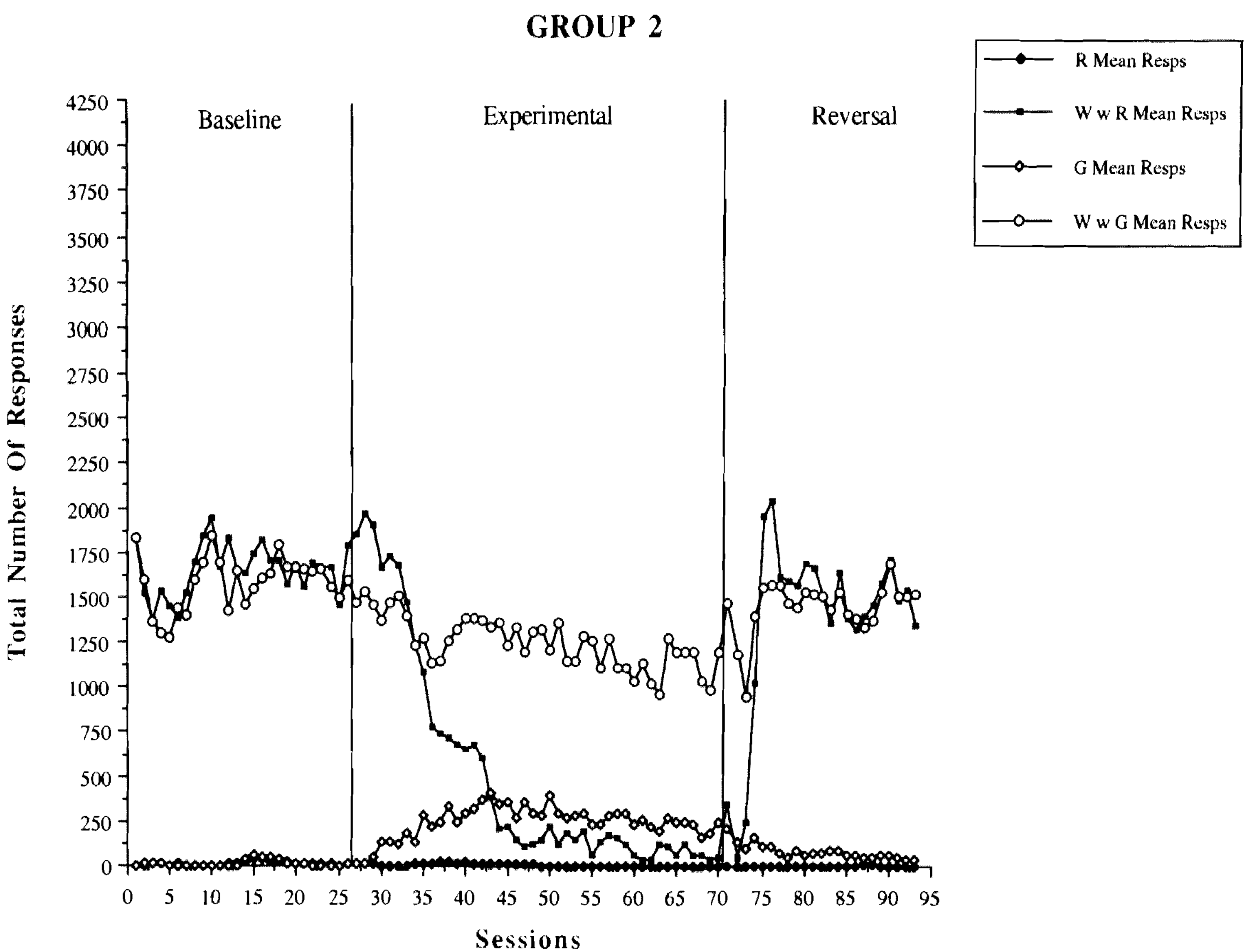
GROUP 3

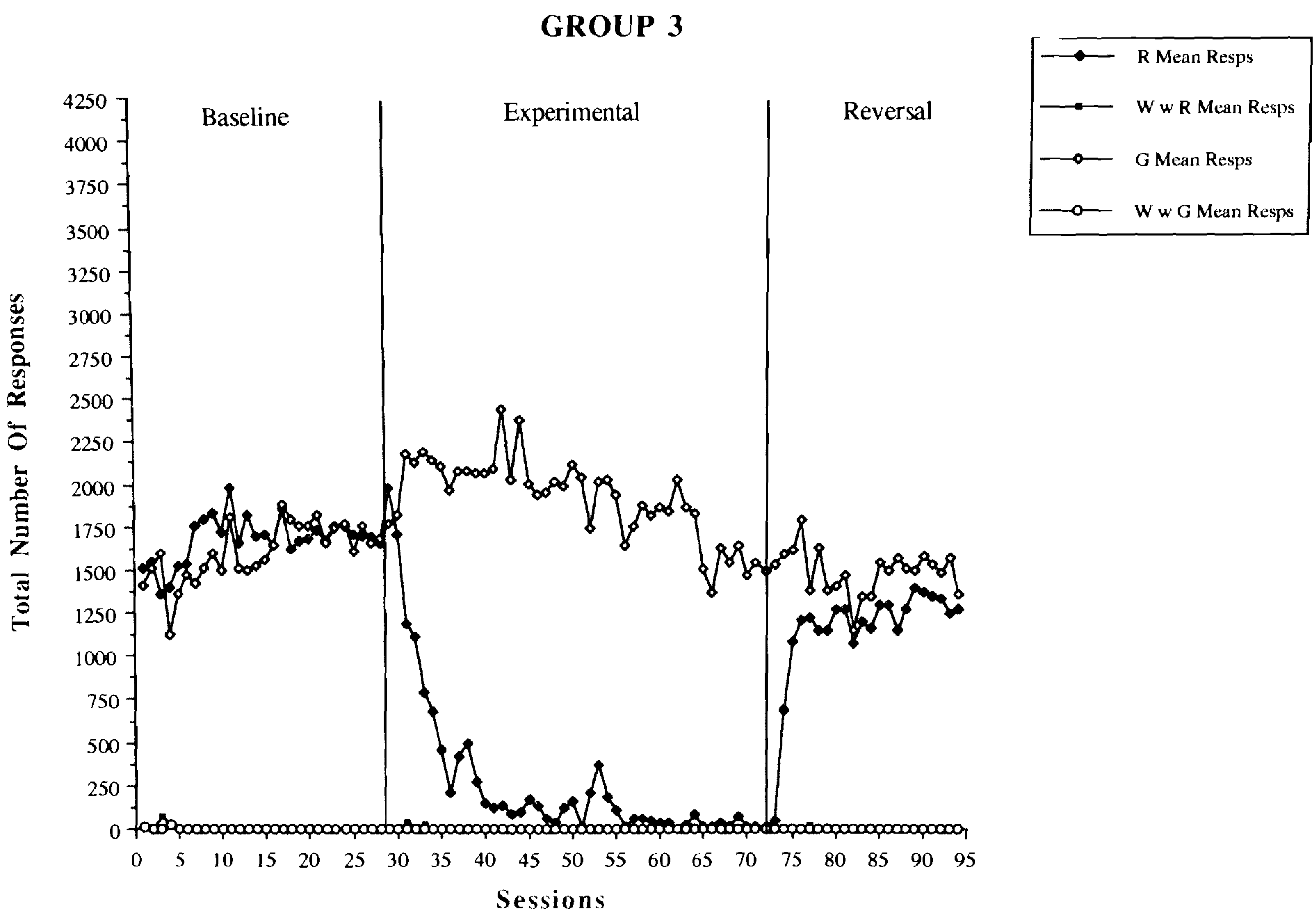

W w G + G Mean Resps
W w R + R Mean Resps
Baseline
Experimental
Reversal
Total Number Of Responses
Sessions
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95

Appendix E

Figures Depicting Group Results with Mean Responses to Each Key Light


GROUP 1
Baseline
Experimental
Reversal
R Mean Resps
W w R Mean Resps
G Mean Resps
W w G Mean Resps
Total Number Of Responses
Sessions
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105


GROUP 2
R Mean Resps
W w R Mean Resps
G Mean Resps
W w G Mean Resps
Baseline
Experimental
Reversal
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
Sessions


GROUP 3
R Mean Resps
W w R Mean Resps
G Mean Resps
W w G Mean Resps
Baseline
Experimental
Reversal
Total Number Of Responses
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
Sessions

Appendix F

Tables of Weights for Each Subject Within Groups

Table 4

Weights for Each Subject in Group 1

Subject	Ad Lib Weight	70% of Ad Lib Weight
H2625	658	461
H2660	630	441
H3095	541	379
H1114	559	391
H2185	524	367

Table 5

Weights for Each Subject in Group 2

Subject	Ad Lib Weight	70% of Ad Lib Weight
H3008	531	372
H3064	590	413
H2141	524	367
H3074	537	376
H2363	634	444

Table 6

Weights for Each Subject in Group 3

Subject	Ad Lib Weight	70% of Ad Lib Weight
H2198	568	398
H2703	612	428
H2797	588	412
H3055	588	412
H3710	590	413

Appendix G

Psuedo-Random Order of Components by Groups

Table 7

Sequence 1 for Group 1

Position in Sequence	Component
1	G-W
2	R-W
3	G-W
4	R-W
5	G-W
6	R-W
7	G-W
8	R-W
9	G-W
10	R-W
11	G-W
12	R-W
13	G-W
14	R-W
15	R-W
16	G-W
17	G-W
18	R-W
19	G-W
20	R-W
21	G-W
22	R-W
23	G-W
24	R-W
25	G-W
26	R-W
27	R-W
28	G-W
29	G-W
30	R-W
31	G-W
32	R-W

(R = Red Key G = Green Key W = White Key)

Table 8

Sequence 2 for Group 1

Position in Sequence	Component
1	R-W
2	G-W
3	R-W
4	G-W
5	R-W
6	G-W
7	R-W
8	G-W
9	R-W
10	G-W
11	R-W
12	G-W
13	R-W
14	G-W
15	G-W
16	R-W
17	R-W
18	G-W
19	R-W
20	G-W
21	R-W
22	G-W
23	R-W
24	G-W
25	R-W
26	G-W
27	G-W
28	R-W
29	R-W
30	G-W
31	R-W
32	G-W

(R = Red Key G = Green Key W = White Key)

Table 9

Sequence 1 for Group 2 and Group 3

Position in Sequence	Component
1	W-R
2	W-G
3	G-W
4	R-W
5	W-R
6	R-W
7	G-W
8	W-G
9	W-G
10	W-R
11	R-W
12	G-W
13	G-W
14	W-G
15	W-R
16	R-W
17	G-W
18	R-W
19	W-G
20	W-R
21	W-R
22	W-G
23	G-W
24	W-G
25	R-W
26	R-W
27	W-R
28	G-W
29	W-R
30	G-W
31	W-G
32	R-W

(R = Red Key G = Green Key W = White Key)

Table 10

Sequence 2 for Group 2 and Group 3

Position in Sequence	Component
1	G-W
2	W-R
3	W-G
4	R-W
5	G-W
6	R-W
7	W-G
8	W-R
9	W-R
10	G-W
11	R-W
12	W-G
13	W-G
14	W-R
15	G-W
16	R-W
17	W-G
18	R-W
19	W-R
20	G-W
21	G-W
22	W-R
23	W-G
24	W-R
25	R-W
26	R-W
27	G-W
28	R-W
29	W-G
30	W-R
31	W-G
32	G-W

(R = Red Key G = Green Key W = White Key)

Appendix H

Presentation of Sequences Across Sessions

Table 11

Presentation of Sequences Across Sessions

Session	Sequence	Session	Sequence	Session	Sequence	Session	Sequence
1	1	27	1	53	2	79	1
2	2	28	2	54	1	80	2
3	2	29	1	55	2	81	1
4	1	30	2	56	1	82	1
5	2	31	1	57	2	83	2
6	1	32	2	58	2	84	1
7	2	33	1	59	2	85	2
8	1	34	2	60	1	86	1
9	2	35	2	61	2	87	2
10	2	36	1	62	1	88	1
11	2	37	1	63	1	89	1
12	1	38	2	64	1	90	2
13	2	39	1	65	2	91	2
14	1	40	2	66	2	92	1
15	1	41	1	67	2	93	2
16	1	42	2	68	1	94	1
17	2	43	1	69	1	95	2
18	1	44	2	70	2	96	1
19	2	45	1	71	2	97	2
20	1	46	1	72	1	98	2
21	2	47	2	73	2	99	1
22	2	48	1	74	1	100	2
23	1	49	1	75	2	101	1
24	1	50	2	76	1	102	1
25	2	51	2	77	2	103	2
26	1	52	1	78	2	104	1